Sky and TELESCOPE

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Vol. III, No. 11
SEPTEMBER, 1944
Whole Number 35
25 cents

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May 30th meteor cloud in progressive stages of disintegration

SOUTH AFRICAN ASTRONOMY

STIMULATED by Dr. Otto Struve's paper in **Popular Astronomy** on "Fifty Years of Progress in Astronomy," the editor of the **Monthly Notes** of the Astronomical Society of South Africa has invited discussions on the future of astronomy in South Africa. Seven active observatories are now in operation there, and of these only the Union Observatory is supported locally; three are southern stations of the American observatories at Harvard, Michigan, and Yale; two are supported from England, and one from Holland. Barring the Radcliffe Observatory which still awaits its large mirror, the other six, according to a note by Dr. R. H. Stoy, are grossly understaffed, partly because of the war. "But even in peacetime, only the Royal Observatory has anything like an adequate staff, while only the Royal Observatory and the Harvard Southern Station have an instrument maker, an essential member of the staff of a really efficient observatory."

Two of the American observatories (Yale and Michigan southern stations) are of an expeditionary nature: one for completing a parallax program, the latter, a double-star survey. Similar southern stations are likely to be established in the future. Dr. Stoy suggests that the cause of astronomy in South Africa might best be advanced by the establishment of an adequately endowed South African Astronomical Institute. "The functions of this institute would be to help existing observatories and any new expedition that might be looking for a location in the Southern Hemisphere.

"The institute would not itself engage in astronomical research but confine its activity to raising and administering funds to help individual observatories or astronomers with special projects . . . . The institute might also run a central instrument making shop and a computing bureau. Its direction would be under the general supervision of the the heads of the various South African Observatories, or, if the major part of the institute's funds are subscribed from overseas, under a committee partly appointed by the International Astronomical Union."

In further discussing the problems connected with astronomical instruments, which are often special and intricate orders, Dr. Stoy makes the thought-provoking suggestion that one of the small, state-owned war supply factories might well be converted for such peacetime work; it would be valuable for producing instruments, and as an institute for research into methods of instrument making.

Although this is but one man's suggestion, which would presumably encounter financial and other difficulties in getting started, the ideas are worthy of serious consideration.

DORRIT HOFFLEIT

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor* HELEN S. FEDERER, *Managing Editor*

Philip Fox

NO one person can adequately describe the career of Philip Fox, for he was a leader in many fields — an astronomer devoted to the most painstaking researches; an inspiring teacher; a scientist who pioneered in the explanation of the physical sciences to the general public through the media of the Adler Planetarium and Astronomical Museum, and the Museum of Science and Industry; an army officer in three wars, culminating in the recent Signal Corps assignment especially suited to his scientific abilities; and in all these capacities, a man whose personality and character earned him the respect and devotion of his associates.

He was born in 1878 in Manhattan, Kan., to parents who were able and eager to encourage his growing interest in the physical sciences. Following his education at Kansas State and Dartmouth colleges, he began his career as an astronomer in 1903 at the Yerkes Observatory, where he remained as assistant and then instructor in astrophysics until 1909 (except for studies at the universities of Berlin and Heidelberg). At Yerkes he had the privilege of being one of the first in a new and productive field, as he worked chiefly with the Rumford spectroheliograph. His observations on the motion of gases in the neighborhood of sunspots, and especially on the rotation period of the sun, have continued to be a guide in the interpretation of solar activity.

In 1909, he went to Northwestern University as professor of astronomy and director of the Dearborn Observatory. Here he had a telescope of only moderate size, but of fine quality, well suited to the precision measurements he undertook. His skill and patience in observing were first devoted to double star measurements. As soon as a new mounting for the lens permitted suc-

(Continued on page 23)

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FRONT COVER: Four consecutive photographs showing rapid changes in the appearance of the cloud left by the meteor of May 20th, over northern Texas. The meteor traveled from right to left, and some of the faint, early parts of the train barely show in the reproductions. These are enlargements 3 1/3 times the original negatives, the scale now being roughly 1° to 4.8 mm., or 1 mile to 8.5 mm. Exposure times and apertures were varied, as, for instance: 1/25 sec. at f/4.5, 1/10 sec. at f/4.5, and 1/5 sec. at f/6.3. Photos by Cpl. Alexander Asn's. (See page 3.)

BACK COVER: Sunspots, taken with the U. S. Naval Observatory 5-inch photoheliograph on July 28, 1941, by Mrs. L. T. Day. The sun is reproduced as it appears in the sky, and on this date its axis of rotation was tipped considerably to the east (left) of north, so that the equator ran from below left center to above right center. (See page 8.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscriptions: $2.50 per year in the United States and possessions, and to members of the armed services; Canada and all countries in the Pan-American Postal Union, $3.00; all other foreign countries, $3.50. Make checks and money orders payable to Sky Publishing Corporation. Send notice of change of address 10 days in advance. Circulation manager: Betty G. Dodd.

Editorial and general offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, but we do not guarantee prompt editorial attention under present conditions, nor are we responsible for the return of unsolicited manuscripts unless adequate return postage is provided by the author.

Advertising director: Fred B. Trimm, 19 East 48th Street, New York 17, N. Y.; ELdorado 5-5750.

Texas Meteor Cloud
May 20, 1944

BY OSCAR E. MONNIG

Texas Observers

A FLASH over the Texas panhandle at 9:04:29 p.m. C.W.T., May 20th (Saturday), was visible for a radius of over 300 miles. If you were inside the circle shown on the map, you had a chance to see some part of the three-second flight of a short but brilliant fireball that went from east to west just 20 minutes after sunset in that region. At the southeastern limits of the area of visibility the sun was down by some 40 minutes, but the phenomenon was viewed against the brightest part of the twilight sky. At the northwestern edge of the circle the sun lacked seven minutes of setting, but in southeastern Colorado it was barely down, and the meteor from this region was seen against the darker background of the twilight bow. General visibility was thus likely better in the eastern half of the circle, the more so since the meteor was more nearly stationary for some points to the westward.

The most widely separated reports actually received were from Burleson, Tex. (Mrs. W. F. Bobbitt), some 15 miles south of Ft. Worth, and Trinidad, Colo., where A. R. Allen measured the observation of a lady who described the meteor as being "so bright she could hardly look at it." It was witnessed in the Clovis, N. M., region, and reported from Bluit, N. M. (nearby), by Mrs. J. H. Bullock. Mrs. Daisy H. Miller saw it from McDonald, Kan., in the northwestern corner of that state. Radio reports said it was seen from Culbertson, Neb.

Over Pampa, Tex., high in the sunlit portion of the atmosphere, the friction encountered by the meteoritic body was tearing dust fragments from its surface by tens if not hundreds of pounds. The intense heat generated was volatilizing much of the substance into gases, some of a visible form; and differential pressures were developing and no doubt building up explosive disruptions that resulted in many more tiny particles of dust being created.

The "air brakes" finally accomplished their purpose of slowing down the space intruder, so that over a region some 13 miles northwest of Pampa its speed was reduced almost below that producing incandescence. Though there is indisputable evidence that the visible meteor continued somewhat beyond this point, it was in this part of the path that the cloud of dust and gases was most intense.

Cpl. Al Asnis was in his car just leaving the Pampa Army Air Field, some 13 miles east of that city, near the small circle shown on the sketch map. He had been a professional photographer and had worked for *Life* magazine before the war. The intense light of the meteor caused him to stop his car and investigate. Recognizing the meteor cloud as a distinctly photogenic object, he went into action with a Rolleicord camera which he had in the car. In 40 to 50 seconds after the meteor's flight (an interval checked at our request by *actual rehearsal*) he took the first picture. Succeeding pictures at about 15-second intervals gave him the series of four reproduced, with his kind permission, as the front cover of this issue. The exposure times and apertures were varied; Eastman Super XX film was used. The last photograph was taken about 90 seconds after the meteor's flight — again timed by actual rehearsal.

We hope these superb pictures will be an inspiration to amateur astronomers to carry cameras and be on the *qui vive* for chances to photograph possible meteor clouds — when films are again more readily available.

The circle indicates the probable limits of visibility of the cloud-leaving meteor over Texas.

Contact prints of two photos by Ray Dudley, the upper picture being nearly identical with the topmost one on the front cover, although Cpl. Asnis was 13 or 14 miles away. The lower picture was taken some two (or more) minutes afterward, and shows considerable disintegration of the cloud.

In the middle of Pampa, Chief of Police Ray Dudley was at his desk some 20 feet inside the north door of the City Hall, and was startled by the light of the meteor. Going out at once he saw the strange meteor cloud and was immediately reminded of a loaded camera on a table inside. A picture was made as quickly as possible with the Zeiss Ikon 15-cm. focal-length lens set at about f/5.8, 1/50 second, also on Super XX film. He estimated it took 40 seconds to do this, and we feel this is highly accurate, because his picture is practically identical with the first view obtained by Cpl. Asnis. Their independent estimates of the time interval are likewise identical.

Some two minutes afterwards, Mr. Dudley took another photo of the rapidly dissipating cloud. The great change in brilliance and the amount of diffusion that had occurred are shown markedly by the fact that only two rounded cloud condensations barely show on the second picture (same exposure and aperture). Indeed, the images are so faint as to be very difficult to reproduce, and the cloud is in such an advanced stage of disintegration by comparison with Asnis' last picture as to suggest that,

if anything, more than $2^m\ 40^s$ had elapsed since the meteor's flight.

From the very beginning we have campaigned diligently for photographs of the meteor cloud. In this we have had the whole-hearted co-operation of the press and associated radios—the Ft. Worth *Star-Telegram* and KGKO; radio station WFAA at Dallas; the Amarillo *Daily News* (KGNC); the Pampa *News* (KPDN); Borger *Daily Herald;* and no doubt other papers which repeated our requests. To all we are most grateful.

On a field trip, some less successful photographs were found at Miami, Tex. (We made it a point to inquire at newspaper offices and drug-store film reception centers at each place visited.) Here Mr. and Mrs. G. W. Philpott and their son were interrupted at their evening meal by the meteor's bright light. Mr. Philpott's call from the back door to "come see" the cloud brought their son, whose interest in photography reminded him of the camera which was ready in a front room. As the writer reconstructed the scene, there was a rapid transit of the whole family through the house to the front yard, where first Mr. Philpott and then Mrs. Philpott "shot" the meteor cloud with the 620 Brownie camera.

But, alas, when the developed films were returned (they went to Kansas City the night before I arrived!), one was blank and the other was an exposure *over* a snowfield picture previously taken. The writer has not yet examined the supposed blank negative; although the film speed and other circumstances were not as favorable as with those at Pampa, the pictures were taken just as quickly, and it is difficult to understand why the cloud was missed — except that strange things are done in the stress of excitement. The double-exposure film seems to show the last part of the train in one corner.

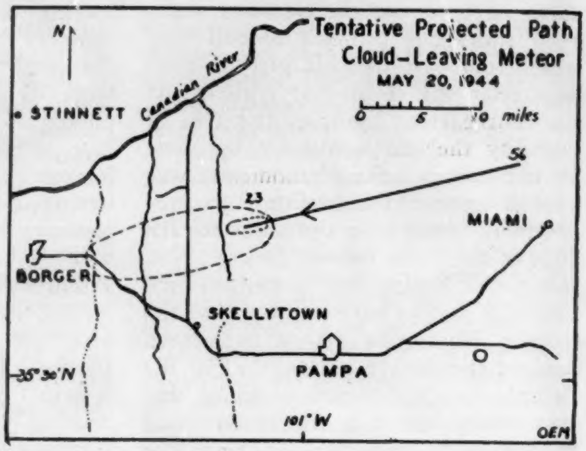
A portion of the meteor cloud probably shows in this picture (upper left), double-exposed over a snow scene previously taken, by Mrs. George Philpott.

At Clarendon, Tex., some 54 miles east of south from the sub-cloud region, Jerome D. Stocking, an amateur scientist of long standing, was notified of the meteor cloud some five minutes after its appearance. Rushing outdoors with his 3A Autographic Kodak, loaded with Verichrome film, he had the bad luck of having the finder fall off, but overcame this difficulty and pointed the camera so as to include the fading clouds. The exposure at f/11, 1/25 second, shows three cloudlets in an approximately vertical row, the middle one brightest and displaced slightly to the right (east) with regard to the other two. The top cloudlet is so faint as to be doubtful except for the fact that Stocking tried a second exposure on "bulb" to get more light; though the camera was moved and the images blurred, all three cloudlets are likewise present. A third picture was blank except for some dots we interpret as defects.

No other photographs or attempted photographs have been reported to us, but if anyone knows of some, we are anxious to be notified of the details. Those who did take pictures have been most generous about lending negatives or freely furnishing prints for scientific use.

In a future article we hope to present some detailed computations based on these photos, as well as discussion and numerical results of a field survey of the meteor. For the present we show a working model map of the meteor's path, with an indicated beginning height of 56 miles (very approximate); dense cloud height of 23 miles (very accurate); true slope of something over 45° (not too certain); and a path azimuth of about 8° south of due west (reliable). The small ellipse indicates the sub-cloud region.

A sketch showing the meteor path; the smaller ellipse indicates the region of dense cloud. Meteorites may have fallen in the area of the larger ellipse.



The larger ellipse is the territory in which we hope to find meteorites. Near its western end may be the final piece or pieces that some witnesses saw carry on. Some six suspected pieces submitted to us by their finders have all been non-meteoritic; all but one came from points outside our indicated field. Most persons make the mistake of hunting for obviously porous pieces, full of gas bubble holes, whereas a meteorite may almost certainly be expected to be quite compact and solid. In this case, they may very well be small pieces of only a few ounces, and of a friable type. But even these "crumbly" meteorites are not honeycombed with holes.

We have done some personal canvassing in the supposed meteorite territory and hope to do more if travel difficulties can be circumvented. Meantime, we hereby stake our claim to the meteorites there found and trust that scientists, both professional and amateur, will recognize it!

ED. NOTE: The author's address is 1010 Morningside Drive, Fort Worth 3, Tex.

AMERICAN ROCKET SOCIETY

On August 6th, according to Science Service, the American Rocket Society announced that meetings of interest to rocket and propulsion engineers, technicians, and experimenters, will be held during the coming year. Regular meetings of this pioneer organization, which was organized in 1931, were suspended during the past two years.

James H. Wyld, engineer of Reaction Motors, is the new president of the society, while Roy Healy is vice-president. Dr. G. Edward Pendray, of the Westinghouse Electric and Manufacturing Co., is secretary. Cedric Giles, of the New York Telephone Company, is editor of *Astronautics,* and Dr. Samuel Lichtenstein is treasurer.

INTERPRETER OF THE HEAVENS

By Wayne M. Faunce

Vice-director, American Museum of Natural History

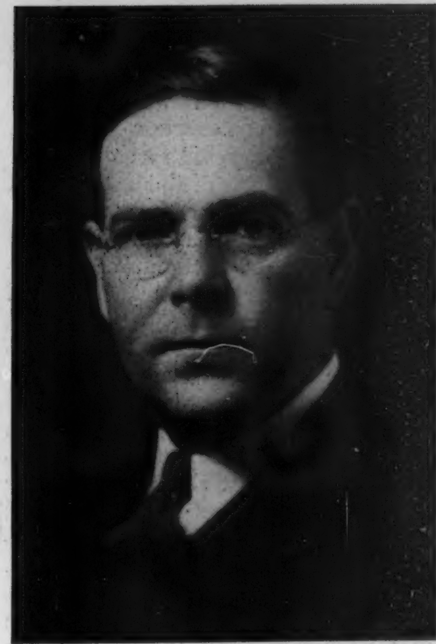
TO the readers of *Sky and Telescope,* who have followed each month his fascinating articles on "The Drama of the Skies" as currently presented in the Hayden Planetarium, the death of William H. Barton, Jr., which occurred on July 7th, is a personal loss. He was a familiar figure to thousands of patrons of the New York and Philadelphia planetariums and enjoyed a wide acquaintance among professional and amateur astronomers. Prof. Barton was not only a regular contributor to *Sky and Telescope,* but was author or co-author of numerous books and pamphlets, more recently on astronomy, but earlier on civil engineering, with which profession he was associated at the beginning of his career. His writing as well as his teaching was remarkable for its clarity, conciseness, and directness.

Since 1942, Prof. Barton had been chairman and curator of the department of astronomy and the Hayden Planetarium at the American Museum of Natural History, New York. In this capacity he not only directed the public demonstrations in the planetarium, but was responsible for the initiation and co-ordination of a variety of scientific and educational activities. Outstanding were his classes in celestial navigation, which are still being conducted both for civilians and, under contract with the United States Navy, for members of the armed forces. Long before Pearl Harbor, Prof. Barton envisioned the importance of developing improved and simplified methods for teaching celestial navigation. As early as 1935, he was regularly delivering special lectures on navigation to midshipmen of the United States Naval Academy.

When the United States became an active belligerent, the facilities of the Hayden Planetarium were made fully available for war purposes, and Prof. Barton lived to see some 30,000 Navy officers receive part of their war training in his navigation classes. Almost up to the day of his death, he was working on problems of polar air navigation and had recently completed an instruction paper on simplified lifeboat navigation which he referred to as "thumb-nail navigation."

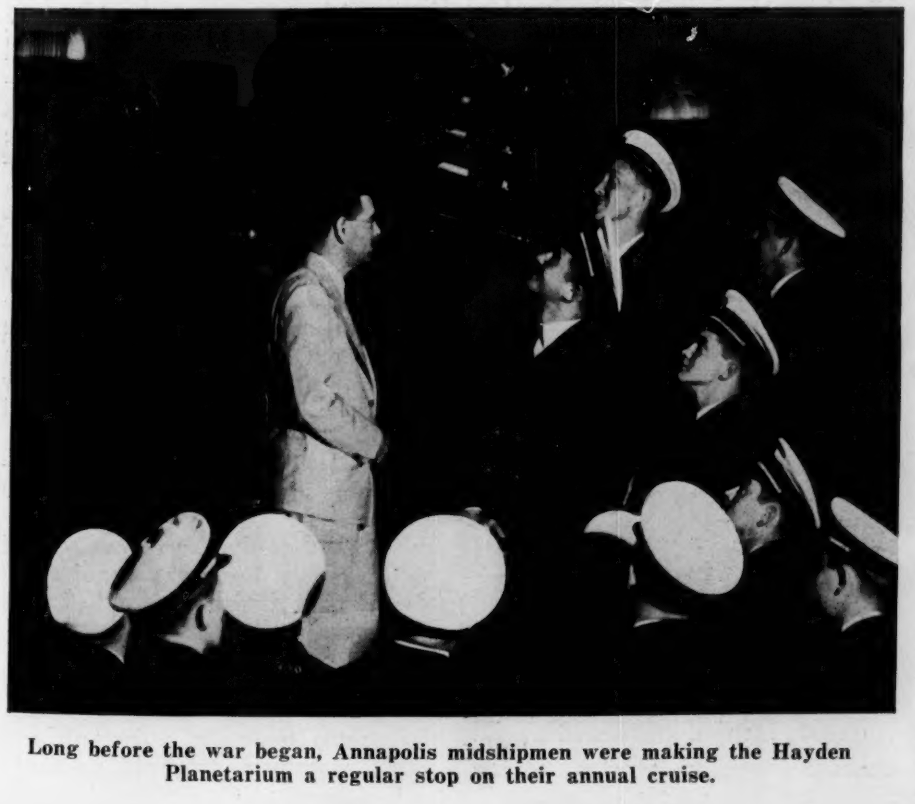
Always actuated by a passionate devotion to patriotic duty, when war was declared Prof. Barton had to make the difficult decision not to elect the more glamorous course — not to put on a uniform and accept an assignment with the fighting forces. His judgment told him (and this was confirmed by his superior officers at the museum) that he would be able to make a greater personal contribution to the prosecution of the war by remaining on duty at the Hayden Planetarium fully to develop its potentialities for war service. Despite the heavy burden of administration and teaching which he carried, Prof. Barton nevertheless found time regularly to serve as a volunteer civilian intercept officer of the New York Fighter Wing at its air-raid detection headquarters. He also gave his time freely as a consultant to several designers and manufacturers of special warfare equipment, and in addition to all this, gave a course in navigation in Queens College, New York.

He was born in Baltimore, Md., July 7, 1893. His death occurred in New York on his 51st birthday. He was educated in the Baltimore public schools and graduated with honors from Baltimore City College in 1911. In 1917, the University of Pennsylvania conferred on him the degree of Bachelor of Science in Civil Engineering. In 1921 he received the degree of Civil Engineer and in 1923, that of Master of Science, both from the same university. From 1917 to 1920, he was associated in engineering work with the United States Bureau of Public Roads, holding various posi-



Blackstone Studios

William H. Barton, Jr.



Long before the war began, Annapolis midshipmen were making the Hayden Planetarium a regular stop on their annual cruise.

tions including highway research specialist. From 1918 to 1919 he was in the United States Army Sanitary Corps in connection with drainage service and construction projects, leaving the Army with the rank of sergeant at the end of this assignment. His teaching career began at the University of Pennsylvania in 1920, and for 10 years Mr. Barton was continuously with the department of civil engineering at his alma mater, first as instructor and subsequently as associate professor of civil engineering engaged in teaching, research, and the testing of commercial materials. In 1930 he joined the faculty of Pennsylvania Military College as professor and head of the department of civil engineering, where he was in administration and teaching for five years.

As early as 1917, Prof. Barton's interest in astronomy was evident. In that year he passed the examination for computer in the United States Naval Observatory, was appointed, but did not accept the appointment. His *Guide to the Constellations*, with S. G. Barton as co-author, was published in 1928. In 1932 he was a member of The Franklin Institute eclipse expedition to Conway, N. H., working on the checking of computations, surveys, and the construction of special astronomical instruments. When the Fels Planetarium of The Franklin Institute, the second planetarium in the United States, was opened in November, 1933, he became one of its lecturers.

Dr. Clyde Fisher, head of the department of astronomy at the American Museum of Natural History, was impressed with Prof. Barton's personality, scientific achievements, and lecturing ability. On his recommendation, Prof. Barton was invited to become associate curator of New York's new planetarium, which offer he accepted. When the Hayden Planetarium threw open its doors on October 3, 1935, he was the only fully experienced planetarium lecturer on hand. With tact and patience he had worked with Dr. Fisher to train a corps of planetarium lecturers who had to be prepared to conduct five or more demonstrations a day to accommodate the enormous numbers of visitors who sought admittance to New York's newest educational attraction. This was a period of inevitable strain for the Hayden Planetarium staff, and Mr. Barton was a bulwark of strength, inspiring confidence among all his coworkers.

Walter Favreau, planetarium artist and craftsman, here shows Curator Barton the fine points of a model of the 100-inch telescope. Planetarium audiences viewed this model (through the perforated dome) at a considerable distance, hence the need for the strong perspective in the design.

In 1938, he was made executive curator of the Hayden Planetarium and succeeded Dr. Fisher as chairman and curator when the latter retired in 1942. Executive officer of the Hayden Planetarium-Grace eclipse expedition in 1937, Mr. Barton was responsible for the design and construction of special apparatus for making observations and photographs of the total solar eclipse of that year in Peru. Although the strenuous work involved in setting up heavy equipment at an altitude of over 14,000 feet had seriously upset his well-being, he nevertheless successfully took charge of the observing squad at Cerro de Pasco.

An engineering training came in handy to Prof. Barton while orienting his camera mountings high in the Andes in 1937, in preparation for observing the solar eclipse.

Prof. Barton was guided by an admirable philosophy of interpreting the achievements of science in a humble manner which not only tended to dispel all mystery but inspired his students and encouraged them to continue their pursuit of scientific knowledge. For his planetarium audiences, this philosophy resulted in cultural entertainment. As would be expected of one of his engineering training, he was a very practical-minded individual. Nevertheless, he possessed a keen imagination, had a sound appreciation of the dramatic and also a good sense of showmanship. These attributes were great assets in developing the popular presentations of astronomical facts in the Hayden Planetarium.

To supplement the Zeiss projector, both for popular demonstrations and in more technical navigation instruction, Prof. Barton's ingenuity and that of the technical staff he directed were responsible for equipment to reproduce such astronomical phenomena as eclipses, aurorae, and enlarged images of the moon and planets. Working models of navigation instruments were developed and, with his technician assistant, Fred Raiser, he worked out a unique adaptation of a device to project the elements of star navigation problems on the domed sky of the planetarium.

A never-failing sense of humor pervaded his formal classes as well as his public lectures. With his naturally salty wit, Prof. Barton always seemed to have just the right anecdote to deepen the impression and "clinch the point." He was a popular radio speaker and his two broadcast series, "Exploring Space" and "Men Behind the Stars," had a wide radio appeal. He was an aggressive advocate of formal arrangements to afford the school

children of New York and its environs the best possible use of the planetarium in their science courses. In 1943, he was responsible for working out an arrangement with the Board of Education of New York City to give special planetarium instruction to high school teachers and their classes in pre-flight aviation training.

This tireless worker had an infectious enthusiasm for his chosen subject, astronomy. He was as unassuming as he was friendly and among his associates was affectionately known as just "Bill." He endeared himself to his friends and colleagues by his cheerful disposition and his constant readiness — yes, eagerness — to assist anyone who came to him for advice. Indeed, this most commendable trait, plus his consuming desire to give his all to the war effort, may have contributed to the break in his health which finally led to his untimely death. His colleagues at the American Museum consider Prof. Barton as truly a war casualty as any soldier killed in action.

In 1920, the young engineer married Celia Mason, who survives him. He and Mrs. Barton had broad interests outside the museum, including a summer home at Stonington, Me., which was largely of their own creation. Interest in music was more than casual. In this diversion he found perfect relaxation and the Bartons spent much time among musical friends. His interest in stereoscopic photography saw fruition in his guide to celestial navigation with stereoscopic charts published last year under the title *Stereopix*. His latest publication, which appeared while he was in the hospital during his last illness, is a unique planisphere which can be used anywhere in both hemispheres of the world.

Prof. Barton was a fellow of the Royal Astronomical Society and the New York Academy of Sciences and an honorary member of the Geographical Society of Lima (Peru). He was also a member of the American Astronomical Society, the British Astronomical Association, the American Association of Museums, the Royal Astronomical Society of Canada, The Franklin Institute, the Rittenhouse Astronomical Society, the Delaware County Institute of Science, the Custer Institute of Research, and the honorary societies of the Sigma Xi and Tau Beta Pi.

A special funeral service was held in New York on Sunday evening, July 11th, to enable Prof. Barton's colleagues at the American Museum and his many local friends to pay their respects. Burial was in Arlington National Cemetery, Arlington, Va., with full military honors, on the afternoon of July 12th, following an impressive service at Fort Myers chapel. Embodied in the resolution adopted by the American Museum of Natural History to express their profound sense of loss in Prof. Barton's death is this fitting tribute:

"In Professor Barton were happily combined the two indispensable qualities which made him outstanding in the work he was called upon to do. He was a man of the greatest scientific accuracy with, at the same time, a unique flair for the popular approach — scientist and showman in one. In this fortunate combination lay the secret of Professor Barton's phenomenal success in initiating and supervising Planetarium activities. He was a man who spared himself no effort, and during the last two years of his life devoted himself unceasingly to the working out of better methods of navigation with a view toward its simplification. . . . He was at his desk early and late. Many a boy in the South Pacific and many a lad crossing the Atlantic will remember this fine teacher as he stood in the Planetarium dome or at his desk— patient, resourceful, humorous and kindly — anxious always to smooth out the problems of the service men who came to him for help. His death takes from us an irreplaceable teacher and a fine man."

Amateur Astronomers

1943 CHANT MEDAL AWARD

Cyril Geoffrey Wates, of Edmonton, Canada, is the recipient of the Chant medal for 1943, the fourth amateur astronomer so to be honored by the Royal Astronomical Society of Canada. He is particularly well known for work in telescope making, and has contributed a number of articles to *Scientific American* in this field.

The award, as the resolution establishing the medal states, is made "to an amateur astronomer resident in Canada; [and] on the basis of the value of the work which he has carried out in astronomy and closely allied fields of original investigation." Previous recipients have been H. Boyd Brydon, Rev. W. G. Colgrove, and Bertram J. Topham.

THIS MONTH'S LECTURES

Cincinnati: On Friday, September 8th, Dr. Keivin Burns, of Allegheny Observatory, will address the Cincinnati Astronomical Association on the subject, "Spectroscopic Notes." The meeting, at 8 p.m., will be held at the Cincinnati Observatory, Observatory Place.

A NEW SMALL OBSERVATORY

The Edward Hayes Morse Memorial Observatory is the gift to Occidental College, Los Angeles, from the widow of Edward Hayes Morse, well-known amateur astronomer and telescope maker. The observatory includes a 15-inch, an 8.5-inch, and a 6-inch reflector, and a solar telescope with a 6-inch objective mirror, all built by Mr. Morse himself. The observatory will be primarily for the students of Occidental, although the public will be admitted on occasion.

In describing the dedication, in the *Publications* of the Astronomical Society of the Pacific, Dr. G. F. W. Mulders states, "Occidental College is proud to take its place among the liberal arts colleges with adequate facilities for undergraduate instruction in the fundamentals of astronomy."

SEPTEMBER ACTIVITIES

At the September meeting of the Detroit Astronomical Society, on the 17th of the month, Dr. R. O. Fuerbringer will act as master of ceremonies for an astronomical quiz on the solar system, the members present forming contesting teams. The public is invited to attend; Room 17, Wayne University, 3:00 p.m.

The Amateur Astronomers Association in New York City is planning its usual classes in astronomy, mathematics, and telescope making, to begin in October, when regular meetings are also resumed. Those wishing to be placed on the mailing list for the leaflet, *Enjoy the Stars*, which describes the society activities and classes of membership, should address the society's secretary, George V. Plachy, American Museum of Natural History, 79th Street and Central Park West, New York 24, N. Y., ENdicott 2-8500.

The annual business meeting and election of officers of the National Capital Amateur Astronomers Association will be held September 9th, at 8 p.m., at the Palisades Field House, stop 15 on the Glen Echo car line. Weather permitting, observing will probably follow the meeting.

SUNSPOTS IN REVIEW

BY WALTER G. BOWERMAN

THE success of life insurance during the 20th century has been chiefly due to the favorable mortality, which has been progressively lowered, especially at the ages at which most of the insured lives are to be found. The worst flareup of unfavorable mortality was that of the influenza epidemic of 1918. The possible causes of that disastrous episode have been carefully studied by the Committee on Atmosphere and Man. Raymond Pearl has shown by the method of partial correlation that the influenza mortality was closely related to that from all causes and even closer to that from organic heart disease. Other investigators have indicated that influenza and heart disease might both be due to some common cause. The committee repeated the experiment, using 22 factors separately. All except climate were eliminated. The elements of temperature, humidity, and storminess remained as more fundamental than any other factors.

In his book, *The Pulse of Progress* (1926), Ellsworth Huntington, of Yale University, has shown some significant figures relating influenza mortality to temperature. The epidemic was progressively more severe in the cities where the temperature was greater, as is shown in this table:

Cities (U.S.)	*Mean Temperature*	*Death Rate*
6 coolest	54° F.	2.6
6 next coolest	57.5	3.0
6 " "	61	3.5
6 " "	63	4.2
6 " "	65	5.0
6 " "	70	5.2

The mean temperature is given for 30 days before the outbreak and for 10 days at the crisis; the death rate is per 1,000 from influenza and pneumonia.

In referring to the work of the committee, Dr. Huntington commented that even climate and weather might be eliminated from the factors affecting influenza mortality, if we had sufficient knowledge to justify substituting variations in solar energy. And many distinguished scientists have stated that all the weather on the earth can be traced back to solar radiation. Of all the factors associated with that radiation, sunspots are the most dramatic and, in the opinion of many observers, the most potent. Hence it becomes of interest to set forth some of the facts and hypotheses which have been discovered in recent years in regard to the activity of sunspots. In doing this, it is necessary to steer a careful course between Scylla and Charybdis, for we shall see that even the doctors (experts) do not always agree in their diagnosis of the conditions.

Certain fundamental facts regarding sunspots have been tabulated for many years. Of these, the number of spots has been tabulated longest and is the index most often studied. The Germans, Wolf and Wolfer, were the pioneers in this part of the work, which has been done systematically since 1833, and by calculations based on meager data extended back to the beginning of the year 1749[1]. At present, W. Brunner, of Zurich, is the chief worker in this field, and his results are published in the *Monthly Weather Review*. The procedure is not so simple as might at first appear, for the spots are usually clustered together into groups. Then, too, clouds or fog or rain may make it impossible to see the sun at all on certain days from any given point on the earth's surface.

The first of these difficulties is dealt with by defining the *relative number* in terms of 10 times the number of

[1]However, from A. Wolfer's paper in the April, 1902, U. S. *Monthly Weather Review*, it is noted that in 1818 and later all the monthly numbers were based on actual observations (although not necessarily at the same observatory). Furthermore, in 1749-1818, five of every 12 monthly numbers on the average were also so derived, the others being partly observations and partly graphic interpolation.

For the years 1749-1754, the spot numbers are, respectively, 80.9, 83.4, 47.7, 47.8, 30.7, 12.2,

Cycle Number	Minimum Year	Yearly Sunspot Numbers - Wolf and Wolfer - For Years After Minimum													
		0	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1755	9.6	10.2	32.4	47.6	54.0	62.9	85.9	61.2	45.1	36.4	20.9			
2	1766	11.4	37.8	69.8	106.1	100.8	81.6	66.5	34.8	30.6					
3	1775	7.0	19.8	92.5	154.4	125.9	84.8	68.1	38.5	22.8					
4	1784	10.2	24.1	82.9	132.0	130.9	118.1	89.9	66.6	60.0	46.9	41.0	21.3	16.0	6.4
5	1798	4.1	6.8	14.5	34.0	45.0	43.1	47.5	42.2	28.1	10.1	8.1	2.5		
6	1810	0.0	1.4	5.0	12.2	13.9	35.4	45.8	41.1	30.4	23.9	15.7	6.6	4.0	
7	1823	1.8	8.5	16.6	36.3	49.7	62.5	67.0	71.0	47.8	27.5				
8	1833	8.5	13.2	56.9	121.5	138.3	103.2	85.8	63.2	36.8	24.2				
9	1843	10.7	15.0	40.1	61.5	98.5	124.3	95.9	66.5	64.5	54.2	39.0	20.6	6.7	
10	1856	4.3	22.8	54.8	93.8	95.7	77.2	59.1	44.0	47.0	30.5	16.3			
11	1867	7.3	37.3	73.9	139.1	111.2	101.7	66.3	44.7	17.1	11.3	12.3			
12	1878	3.4	6.0	32.3	54.3	59.7	63.7	63.5	52.2	25.4	13.1	6.8			
13	1889	6.3	7.1	35.6	75.0	84.9	78.0	64.0	41.8	26.2	26.7	12.1	9.5		
14	1901	2.7	5.0	24.4	42.0	63.5	53.8	62.0	48.5	43.9	18.6	5.7	3.6		
15	1913	1.4	9.6	47.4	57.1	103.9	80.6	63.6	38.7	24.7	14.7				
16	1923	5.8	16.7	44.3	63.9	69.0	77.8	65.0	35.7	21.2	11.1				
17	1933	5.7	8.7	36.1	77.1	114.4	109.5	88.7	68.3	47.0	30.6				

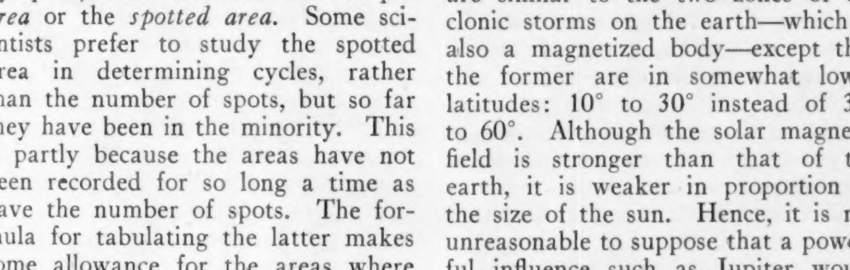
groups plus the number of separate spots. Thus $N = K\ (10g + n)$ where K is 0.6 for Zurich and may range from 0.5 to 2.0. Sometimes, observer A will call a cluster one group while observer B will call it two groups, and thus A might find N to be $10 + 5 = 15$; B will call it $20 + 5 = 25$. For this reason and also on account of the clouds and other obstacles to a view of the sun, observations are taken from many parts of the earth. While Dr. Brunner's first numbers are provisional, they are later adjusted to give the final official sunspot numbers. The monthly numbers are an average of the daily observations and the yearly numbers are an average of the monthly ones. Usually, the provisional yearly numbers do not differ markedly from the final numbers. The latter are published periodically in the *Bulletin* of the American Meteorological Society and also in similar literature in other countries.

Another item which is tabulated nowadays is the proportion of the surface of the sun which is covered by spots; this is known as the *sunspot area* or the *spotted area*. Some scientists prefer to study the spotted area in determining cycles, rather than the number of spots, but so far they have been in the minority. This is partly because the areas have not been recorded for so long a time as have the number of spots. The formula for tabulating the latter makes some allowance for the areas where many spots are grouped together.

A third item of distinct value is the position (latitude and longitude) on the sun where the spots appear. Curiously enough, they have been observed only within two bands across the sun, one north and the other south of the solar equator. These bands extend as a rule only from 40° to 5° from the equator, and the vast majority of the spots are to be found between 30° and 10° of latitude. The maximum number of spots is usually reached at about 15° to 18°. This peculiar band effect has suggested

Langley's drawing of a sunspot group.

that the sunspots may be caused more by an electrical than a gravitational or tidal influence. Birkeland has found that when a globe is magnetized the vortices group themselves in bands parallel to the magnetic equator, and as the degree of magnetization by the foreign body increases, the bands move toward the equator. The zones in which sunspots occur are similar to the two zones of cyclonic storms on the earth—which is also a magnetized body—except that the former are in somewhat lower latitudes: 10° to 30° instead of 30° to 60°. Although the solar magnetic field is stronger than that of the earth, it is weaker in proportion to the size of the sun. Hence, it is not unreasonable to suppose that a powerful influence such as Jupiter would hold the sunspots nearer to the sun's equator than are terrestrial storms held to the earth's equator. Furthermore, in the United States and Canada, the cyclonic storms begin in high latitudes, increase in strength and then migrate to lower latitudes. Somewhat similarly, in accordance with Spoerer's law, each sunspot cycle begins with a few spots at about 30° on either side of the solar equator. As their activity increases, new spots break out nearer and nearer to the equator until about 10° is reached, when the cycle gradually dies away.

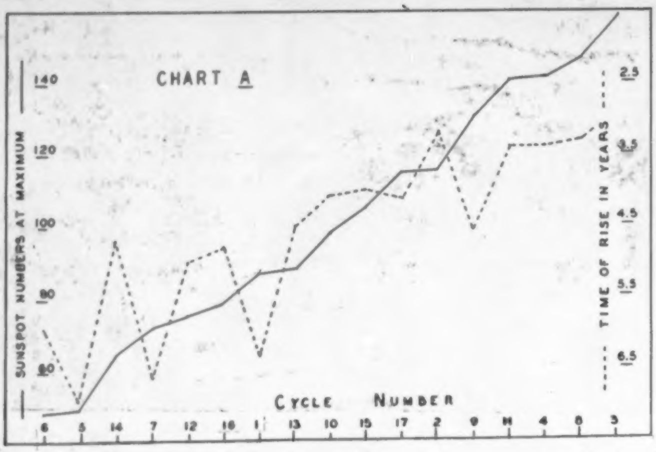


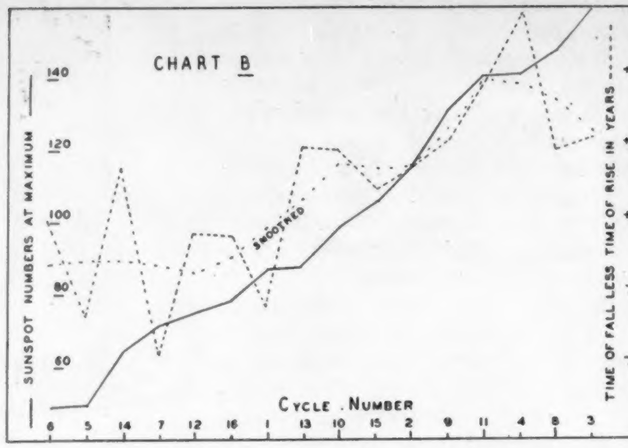
This chart shows changes in position and magnetic polarity of sunspots. The letters R and V stand for red and violet components of spectral lines polarized by the Zeeman effect, whereby the magnetic polarity of the spots is determined.

For one or two years a new cycle of sunspots is arising in high latitudes of the sun before the old cycle has finally died away in the lower part of the spotted zone. This takes place simultaneously on both sides of the sun's equator. In the official sunspot numbers both sets of spots are combined, and thus it is often difficult to obtain agreement as to just when a minimum is reached. The increasing numbers of the new cycle tend to offset the diminishing numbers of the waning series. As there are often substantial variations from month to month, what may at the time seem like the bottom of the curve may later appear to be but a minor fluctuation, more than offset in the next month. It is customary, however, for the astronomers concerned to reach an agreement so that future calculations may be on a uniform basis. For this purpose, the year is divided into tenths. For example, the latest officially determined minimum was at 1933.8 and the latest maximum at 1937.9. This decimal arrangement is for convenience in making calculations.

The sunspots are not equally divided between the northern and southern solar hemispheres. Prior to 1850 they seem to have been most frequent in the northern hemisphere, and then for at least 50 years, in the southern hemisphere.

Although such matters as these are not included in the official tabulations of sunspot numbers, they form the subject of separate observations by a number of experts. Harlan T. Stetson, of Massachusetts Institute of Technology, has for some time been keeping a separate record of the old cycle and the new cycle of sunspots. This is of particular interest in his work dealing primarily with the electrical and magnetic disturbances of the upper atmosphere as they affect radio reception. The polarity of sunspot





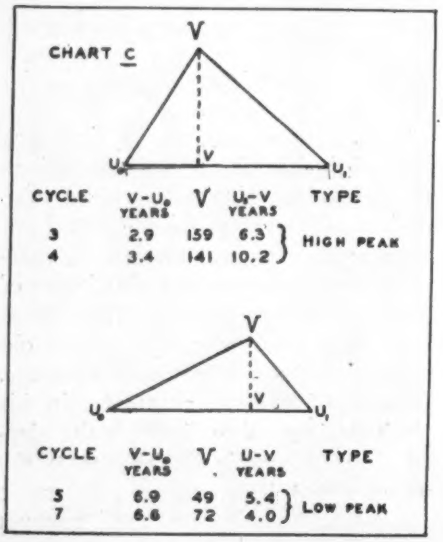
magnetism changes as the spots pass through each minimum. In one such change they pass from positive to negative, and in the next from negative to positive, which leads many to believe the complete cycle to be twice the average 11-year period. The possibility of this magnetic change appearing in radio reception effects makes it necessary to keep the cycles separate in Dr. Stetson's records.

Similarly, Charles G. Abbot, of the Smithsonian Institution at Washington, D. C., has been a leading American pioneer in the study of plans for harnessing the energy of the sun. He has instituted many procedures for recording the amount of solar radiation and its periodic fluctuations. This has led to attempts at forecasting temperatures and precipitation for months in advance at different cities in the United States. Since this country entered World War II, the details of the latest methods of weather forecasting have been kept secret in view of their military value.

Several investigators have sensed some relationship between (*a*) the interval in years between a minimum and its succeeding maximum (that is, the time of rise to maximum) and (*b*) the sunspot numbers at the maximum. In Chart A, the 17 cycles are arranged in order according to the maximum sunspot numbers (Zurich), and, the relationship to the years of rise to a maximum being *inverse,* the the tabulation of those years is shown inverted. The general inverse relationship is evident, although irregular.

A somewhat similar relation is shown in Chart B. This shows the time of fall (from maximum to the next minimum) less the time of rise (from minimum to maximum), and indicates that this excess tends to vary *directly* with the sunspot numbers at maximum.

The facts brought out in Charts A and B may be clarified by considering, respectively, the four extreme cases, namely those with shortest rise, longest rise, shortest fall, and longest fall. For convenience, these four cycles are summarized in Chart C, from which the general nature of the curves will be apparent. When a sunspot cycle has a high peak, it takes only a short time to reach that summit but a long time to reach its trough; while for low maxima the rate of rise is slow and the fall relatively precipitate.

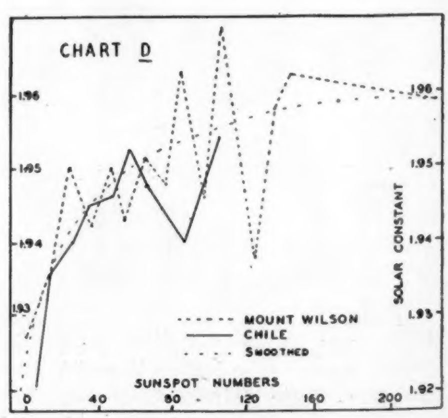


While a sunspot cycle is in progress, we are interested in predicting when it will reach its minimum. From observation of the numbers for the cycles 1 to 16, it may be stated that the minimum tends to occur one year after the sunspot numbers are 1/7 of those at the maximum; also, the minimum tends to occur 2/3 of a year after the spots are 1/10 of the maximum.

Some of the most devoted students of the sun place their particular interest in the sunspot numbers, and others in the amount of solar radiation. In *World Weather,* H. H. Clayton has graphed the relation between these two indexes of solar activity. In Chart D, the figures are indicated for Mount Wilson Observatory (1905-1920) and for Chile (1918-1924). As there were more than 2,000 observations, the smoothed curve shows a very clear relationship. The sun's heat radiated to the earth tends to increase with the number of sunspots. However, in a later paper (Smithsonian Institution, *Annals* of Astrophysical Observatory, Vol. 6, p. 196, 1942) Dr. Abbot found no such relationship for the data of 1920-1939. Further research on this matter must await the collection of additional material; for with a longer period under observation some differentiations could be made which might bring out relationships necessarily obscured by cruder tabulations. Dr. Stetson has stated, in a personal letter to the author:

"There is every evidence from ionospheric investigations that the output of the solar radiation, especially in the extreme ultraviolet, is 100 to 150 per cent greater at sunspot maximum than at sunspot minimum. It would indeed be surprising if one did not detect some of this in the values of the solar constant, unless some exactly compensating absorption is encountered in the atmosphere that escapes the method employed in reducing the observed values to the values of solar radiation outside the atmosphere."

Clayton points out that "evidence



that the sun's radiation varies with the sunspot period is found in the fact that the polar caps of Mars when turned toward the sun lessen in size when the spots are many, and vice versa. Variations in the amount of light reflected by Jupiter have also been found to vary with the sunspot period."

In *Earth and Sun,* Huntington makes an interesting point in discussing possible causation of sunspots. He says, "The planets do *not* supply the energy shown in sunspots and other movements of the sun's atmosphere. The energy derived from them may be no more than that of pressing a button, which starts an explosion. When a little eddy is once started the slight movement so generated may be reinforced by stresses due to the rapid cooling of the sun's outer layer, or to the sun's varying rate of rotation at different latitudes."

To the student of solar-terrestrial relationships there are many pitfalls, and one must avoid too hasty generalizations. The fact that the polarity of sunspots changes at every minimum may explain many apparent contradictions. Clayton has shown that certain relationships to temperature, pressure, and precipitation are reversed in some parts of the world as compared with other areas. Thus, while a tropical river such as the Nile shows a maximum height near sunspot maxima, the reverse has been found for rivers in temperate regions such as the Parana River in the Argentine area. Recently, observations of sunspots in the central zone of the sun show that their numbers differ from the official over-all sunspot numbers. Thus, Garcia-Mata found a huge maximum at the central zone in October, 1929, while the official maximum of all zones combined was in May, 1928, 17 months earlier.

In the years to come there will doubtless be many articles written about the sun's influence on the earth. The constructive work will be of three major types: 1. The painstaking and patient accumulation of facts in many parts of the earth and in many seasons and years. 2. The tabulation of relationships among those facts, an estimation of their value by statistical methods, and the tentative establishment of laws regulating them. 3. The setting forth of hypotheses which will enable one to temporarily view the facts from a new and simpler aspect. The present article is chiefly a review of some of the major work which has been done under the second of these headings.

ASTRONOMICAL ANECDOTES

A SALAD, SOME ANAGRAMS, AND A TERCENTENARY

NOW that the vestigial nebula of Kepler's supernova of 1604 has been discovered at Mount Wilson by dint of long and tricky exposure through the world's largest operating telescope, it might be well to see what Kepler had to say concerning the telescope. In the preface to his *Dioptrics* (1611), he wrote,

> O telescope, instrument of much knowledge, more precious than any scepter! Is not he who holds thee in his hand made king and lord of the works of God? Truly
>
> All that is overhead, the mighty orbs
> With all their motions, thou dost subjugate
> To man's intelligence.

He was a strange man, of incomprehensible energy, making strange mystical guesses and riding hobbies until they dropped dead. In view of some of his weird ideas, it seems strange to find him condemning others for wild guesses. For example, some "scientists" of his day believed the supernova of 1604 to have been produced by a fortuitous concommittance of atoms (whatever that may mean). Kepler commented as follows:

> I will tell these disputants, my opponents, not my own opinion, but that of my wife. Yesterday, when I was weary with writing, my mind being quite dusty with considering these atoms, I was called to supper, and a salad I had asked for was set before me. "It seems, then," said I, aloud, "that if pewter dishes, leaves of lettuce, grains of salt, drops of water, vinegar and oil and slices of egg had been flying about the air from all eternity, it might at last happen by chance that there would come a salad." "Yes," says my wife, "but not nice and well-dressed as this of mine is!"

This episode and many others as human and as magnificent are beautifully told — indeed, *so* beautifully told—in Alfred Noyes' *Watchers of the Sky.* If you haven't read it or had it read aloud to you, you're only half an astronomer! For Noyes has caught the spirit of science in epic verse in a way no one has achieved before. The lines are chock-full of the history of astronomy; one after another the little odds and ends are gathered up to form a web of romance and scientific accuracy that is unbelievably fine.

I wonder how long Kepler worked on Galileo's first famous anagram? The Paduan had made an observation which he buried in the letters: *smaismrmilmepoetalevmibvnenvgttavir as.* Kepler guessed that he meant: *Salve umbistneum geminatum Martia proles,* which is translated as: "Hail, twin companionship, children of Mars." We do know that Kepler believed that Mars should have two "children" or satellites. In the above passage, however, the letters don't come out exactly right and I have never found the word *umbistneum* (companionship) in a Latin dictionary.

Actually, Galileo had scrambled the letters of the sentence: *Altissimum planetam tergeminum observavi,* which translates to: "I have observed the farthest planet triple." In 1610, he saw two appendages or satellites at the sides of Saturn; he wrote the anagram at that time and was perplexed when in 1612 the ball of Saturn stood apparently alone.

It was Huygens who in 1656 announced the true nature of these appendages first seen by Galileo. He, too, used an anagram: *aaaaaaacccccd eeeeeghiiiiiiillllmmnnnnnnnnnoooopqr rstttttuuuuu.* In 1659 he revealed the solution: *Annulo cingitur, tenui, plano, nusquam cohaerente, ad eclipticam inclinato.* This means, "It is encircled by a ring, thin, plane, nowhere attached, inclined to the ecliptic."

Galileo's great fortune in being the first to turn a telescope to the sky was well stated by Castelli, his first disciple and lifelong friend: "The noblest eyes that Nature ever made, which saw more than the eyes of all who are gone, and opened the eyes of all who are to come." It must have been some kind of compensation of Fate that made Galileo blind before his death.

September of this year includes a tercentenary of astronomical importance. In 1671, Picard went to Denmark to see the remains of Tycho Brahe's establishment at Hveen; he found an assistant for himself in Denmark and took him back to the Paris Observatory. The young Danish astronomer was Ole Roemer, born at Aarhus in Jutland on September 25, 1644. He worked in Paris for 10 years, his most spectacular discovery being that light travels with a finite velocity. By observing the eclipses of Jupiter's satellite Io, he was able to announce the value of 22 minutes for the time required for light to traverse a diameter of the earth's orbit. The modern value is 998.6 seconds, or 16.64 minutes. He was known also in connection with the Roemer thermometer scale; he established the epicycloid as the proper curve for gear teeth; and was the inventor of the meridian transit instrument.

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AMERICAN ASTRO

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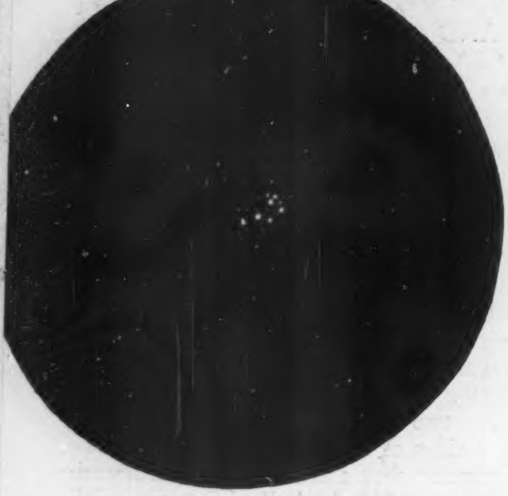


The cluster of the Pleiades.

The Brightest Pleiades

DR. J. A. PEARCE, director of the Dominion Astrophysical Observatory at Victoria, B. C., where the study of stellar spectra is carried on with a 72-inch telescope, sent a paper giving the results of his studies of the motions and physical characteristics of the 12 brightest stars in the Pleiades, all of them blue stars of class *B*. The cluster as a whole is estimated to comprise at least 500 stars, symmetrically distributed throughout a spherical space of three degrees radius about Alcyone, the brightest Pleiad. The Pleiades are packed together about 30 times as densely as are the stars in the sun's vicinity.

Dr. Pearce stated that the reason astronomers had not previously completed spectroscopic data on the velocities of the 12 bright Pleiads is that their spectra are exceedingly difficult to measure accurately, the spectral lines being very wide, nebulous, and lacking in contrast. In general, for each star only six or seven diffuse lines of hydrogen and helium are available for measurement. The poor quality of the spectral lines undoubtedly has discouraged students of stellar motions, leaving the total motion of the cluster an unsolved problem.

Dr. Pearce has collected some 214 observations of 10 of these stars made during the past 40 years, and combined these with 111 unpublished velocities of his own. From these he finds that the Pleiades appear to be receding from us at a speed of about five miles per second, a figure in good agreement with that predicted by observations of the apparent motions of these stars across the face of the sky.

Although these are extremely blue stars, they are to be classed as dwarfs, like the sun. Alcyone outshines the sun 730 times, but the average of the 12 stars is only 200 times the sun's brightness. Their average diameter is only 2.6 times the sun's. This comparatively small diameter, combined with the already observed rapid rotation of these particular stars, accounts for the unusually diffuse character of their spectral lines.

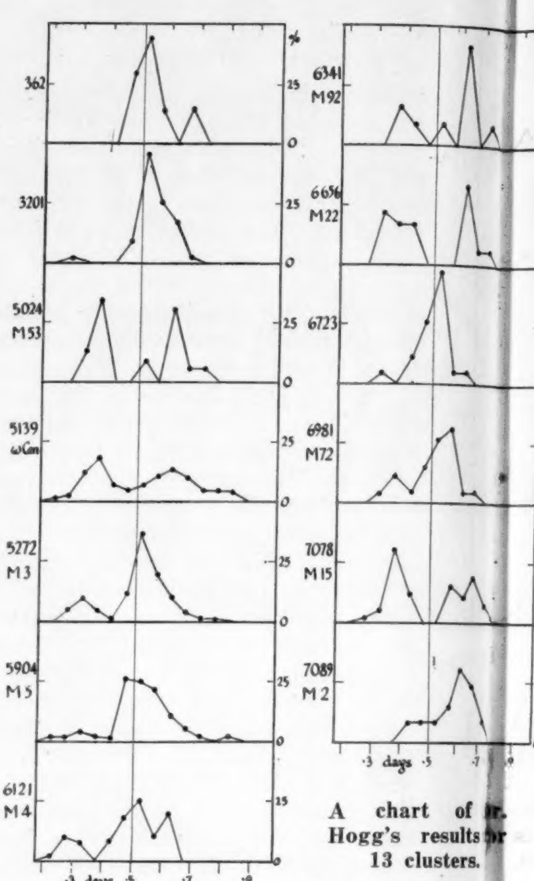
The distance of the cluster, obtained from Dr. Pearce's work, is found to be about 240 light-years, in close agreement with the results from other methods.

Approximately 150 spectra of the fainter *A* to *G* stars in the cluster have been secured by Dr. Pearce, and he expects to discuss their motions and characteristics at a future date.

Cluster Cepheids

PULSATING stars in certain globular clusters studied by Dr. Helen Sawyer Hogg, of David Dunlap Observatory, seem to be segregated in a peculiar fashion. During the past year, she has used plates taken at Harvard (South Africa) and Steward (Arizona) observatories to find eight new variables in the globular cluster M22, in Sagittarius, making the total number of variables known in this cluster to be 25. Of these, 18 have periods of less than a day and form two separate groups, one with periods around one third of a day and the other about two thirds of a day. There are no variables in this cluster with periods around half a day—in the interval 0.44 to 0.61 day.

Yet, half a day is the most frequent period for cluster-type Cepheids found elsewhere in the galaxy; it is also the interval in which periods, if they exist, are most readily determined. Bailey, in 1919, had pointed out a similar gap in the cluster M15, but in M22 it is more pronounced. Two other clusters, making four in all, show the same gap, while nine other clusters containing at least seven cluster variables each show a maximum frequency at periods close to half a day, with only a slight secondary maximum or none at all, as shown in the accompanying chart.



A chart of Dr. Hogg's results for 13 clusters.

"A priori," Dr. Hogg said, "there is no reason for a maximum at two thirds of a day to be associated with a second maximum at one third . . . . The maximum frequency of the cluster-type periods is not correlated with any obvious characteristic of the clusters such as galactic latitude or longitude, or number of long-period Cepheids. It would nevertheless appear to be of some significance for theories of stellar variability or the origin of globular clusters."

Really Red Stars

TWO METHODS for finding red stars have been employed by Senor Guillermo Haro, of Tonanzintla Observatory, during his recent work at Harvard College Observatory. The first method resulted in his discovering a star which appears nearly 500 times as bright on plates sensitive to red light as on ordinary blue-sensitive plates. The finding of this star led him to look for others; of seven more he found another nearly as red as the first one. The second method makes use of the fact that a refracting telescope ordinarily does not bring red and blue light to the same focus.

Astronomers usually have to explain why bright red giant stars, such as Betelgeuse in Orion's shoulder and Antares in the Scorpion's heart, fail

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to take as good a picture as do their neighboring stars in the same constellations. Red stars give out most of their energy in the red and infrared regions of the spectrum, and therefore they appear comparatively faint on photographs on emulsions sensitive mostly to blue and green wave lengths. To photograph such groups as Orion and Scorpius as they appear to the eye, films sensitive to yellow light and a yellow filter may be used; magnitudes based on such pictures are called *photovisual.* With emulsions sensitive to red light and with red filters, photored magnitudes can be determined.

On blue plates, Senor Haro's first star has an average magnitude of 14.75 photographic, placing it among the average run of rather faint stars, quite inconspicuous on blue plates. But on red plates it stands out strongly, for it has a photored magnitude of 8.10, or a difference of nearly 500 times in relative brightness. Its photovisual magnitude is about 9.75. This star appears to be slightly redder than one discovered in 1935 by F. K. Edmondson and A. M. Rogers, then at Lowell Observatory, Flagstaff, Ariz.

Both Edmondson's star and Senor Haro's object are variable, the latter with a range of 1.5 magnitudes, or about four times in brightness. The star's spectral type is *N;* all stars of this class are known for their redness. It is apparently a giant star, millions of times larger in volume than the sun; but it must be considerably cooler at its surface than stars like Betelgeuse and Antares — its surface temperature is probably about 1,500 degrees centigrade.

Senor Haro stated that this star led him to search for other very red stars in the same region of the sky—that of Hercules-Vulpecula — and he applied a method formerly developed by V. M. Slipher, of Lowell Observatory, and G. Z. Dimitroff, of Harvard. They make use of the differential refraction of a lens telescope. In the 8-inch Ross-Lundin camera at Harvard's Oak Ridge station the distance between the points of red and blue focus is one fifth of an inch. The Mexican astronomer used this telescope, working without filters and using Eastman panchromatic plates which are sensitive to most wave lengths of visual light.

At the blue focus of the Ross-Lundin telescope, the blue stars appear normal, having small, round images, but each red or orange star photographs as a tiny black dot surrounded by a halo. The black dot is produced by the small amount of blue light in the red star and the halo is the result of the much greater amount of red light being photographed out of focus.

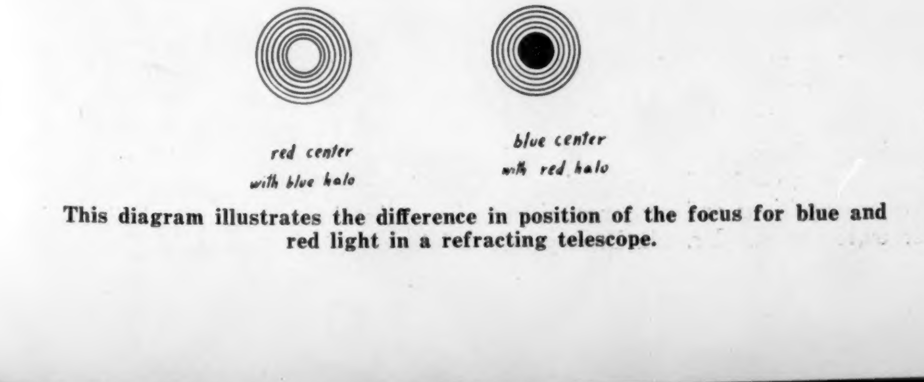
Senor Haro's second red star is so red that, when photographed by this method, the blue central dot is entirely absent; there appears only a halo of fairly uniform brightness with a central hole. The star's photographic magnitude is 16.40, photored magnitude 9.90, a difference nearly as great as that of the first star. In approximately 250 square degrees of the sky, eight stars whose photographic and photored magnitudes differ by more than four magnitudes have been found, Senor Haro's search being complete down to the 11th magnitude photored.

The second star found by Senor Haro appears here as a faint halo, without central nucleus, about 1 1/3 inches from the top center. Note several other stars with haloes of varying intensities.

Negative Ions

PHYSICISTS may again turn to the stars for laboratory conditions difficult to produce on earth, according to a proposal made by Drs. Rupert Wildt, of Leander McCormick Observatory, and S. Chandrasekhar, of Yerkes Observatory. The search will be for an abundance of negative ions, neutral atoms to which free electrons have attached themselves. Positive ions, atoms from which electrons have been removed, are common enough, but the negative ions of such elements as hydrogen and oxygen have been observed in only minute quantities in the mass spectrograph.

It has so far proved impossible to prepare negative oxygen and hydrogen ions in such relatively large amounts as would permit their spectra to be examined by conventional laboratory procedures. In the stars, however, tremendous quantities of mixed gases are being observed, and Drs. Wildt and Chandrasekhar point out that the abundance of hydrogen in the sun makes it fairly certain that many neutral hydrogen atoms will pick up some of the myriads of free electrons resulting from the ioniza-



This diagram illustrates the difference in position of the focus for blue and red light in a refracting telescope.

tion of more easily ionized and also abundant elements, such as sodium. Therefore, they conclude that at the temperature of the sun's atmosphere, a continuous absorption of light is produced by the negative hydrogen ions. That is, as such atoms absorb energy from the solar radiation, their excess electrons are released; the absorption reduces the brightness of the background of the solar spectrum against which the well-known Fraunhofer lines are observed. Solar spectroscopists may find cause for concern in this prediction, for it may affect their measures of intensities of the spectral lines.

In the case of oxygen atoms which have picked up negative electrons, at the sun's temperature they will be of negligible quantity, but in the coolest stars, negative oxygen atoms may actually become relatively abundant because at lower temperatures electrons are bound more tightly to oxygen than to hydrogen atoms. The negative-ion-oxygen absorption should begin, theoretically, at a rather sharp edge in the violet part of the spectrum and extend far into the ultraviolet. Several years ago the Swedish astronomer, B. Lindblad, found just such an absorption edge in the spectra of the giant red stars of class *M*. These stars are much cooler than the sun, and Dr. Lindblad's observations would appear to confirm the theoretical work of Drs. Wildt and Chandrasekhar.

Eclipsing Stars

THREE astronomers reported observations of eclipsing variable stars. Dr. Sergei Gaposchkin, of Harvard College Observatory, discussed the stars SX and RX Cassiopeiae, which he finds to have smaller dimensions in photographic than in visual light, while Carlos U. Cesco, of La Plata, and Jorge Sahade, of Cordoba, reported their results of spectroscopic studies of the stars BD Virginis and AR Monocerotis. A Wolf-Rayet eclipsing system and the star Upsilon Sagittarii were also described by Dr. Gaposchkin.

Each of the eclipsing systems in Cassiopeia comprises a white *A*-type star and a yellow *G*-type star. Dr. Gaposchkin has examined a large number of photographs of star fields containing these stars, obtaining light curves as recorded on ordinary blue plates. From these curves he is able to compute the characteristics of the orbit in each case; also, he obtains the sizes of the stars. The same computation has been made from light curves in ordinary visual light, and a comparison with the photographic results shows the *A* star in each case to be of considerably smaller dimensions in photographic than in visual light.

Kosirev, a Russian astronomer, has shown that this effect may be expected from stars which are composed of very small nuclei and very extended atmospheres. Spectroscopic observations made at Yerkes seem to confirm the presence of a thick envelope around the *A* star, an envelope which probably engulfs the entire system, including the giant *G* star.

In RX Cass, further complication arises from the fact that one of the two stars (which one is not known) is a long-period variable, undergoing every 517 days a regular fluctuation in brightness.

The star BD Virginis is a faint eclipsing variable, its components revolving in a period of 2½ days. Studies at McDonald Observatory have shown that the spectrum is abnormal, which led Senor Cesco to determine its spectroscopic orbit, using 34 spectrograms taken with the 82-inch reflector. His results show that the masses of the stars are somewhat smaller than the average for spectral type *A*, which is that of the star whose spectrum is visible.

Working at Yerkes with Senor Cesco, another Argentine astronomer, Senor Sahade, has used 39 McDonald spectrograms to determine the orbit of AR Monocerotis. It appears to be composed of a giant *K* star surrounded by an envelope of calcium gas excited by the secondary star, which is probably of *F* or *G* type.

In commenting on Senor Sahade's paper, Dr. Cecilia Payne Gaposchkin, of Harvard, stated that the star AR Monocerotis is another case nearly like those of RX and SX Cass, the white star appearing much smaller in photographic than in visual light. Further comment by Dr. Otto Struve, of Yerkes Observatory, was partly to the effect that velocity shifts do not alone explain the various "radii" which a star exhibits; there is probably some other phenomenon which renders a stellar atmosphere opaque in one part of the spectrum and transparent in another, producing results like those found for these stars.

Yale Catalogues

SINCE 1933, six volumes of the Yale Observatory *Transactions* have been published, containing zone catalogues from +20° to +30° and from —10° to —30°. These catalogues give the positions and proper motions for 69,135 stars. Dr. Ida Barney, of Yale University Observatory, reported on further progress in other zones which will eventually complete the catalogues from +30° to —30°. The catalogues to be published will fill six more volumes of the *Transactions* and will include approximately 58,000 stars.

Dr. Gustav Land, also of Yale, reported on corrections to the orbit of the asteroid Mnemosyne, one of the 16 minor planets for which Yale, in collaboration with Allegheny Observatory, is securing accurate photographic positions, with a view to determining systematic corrections to star positions in fundamental catalogues. Thus the tiny asteroids have an important role in one of the most essential of modern astronomical programs.

Spectra of O-type Stars

SPECTRA of the hottest stars of the ordinary sequence, that is, of the *O*-type stars, have been examined by Dr. R. M. Petrie, of the Dominion Astrophysical Observatory at Victoria, B. C. In a paper sent by him, Dr. Petrie reports the results of measurements of the intensities of the principal absorption lines in 19 of these rare stars. Eleven lines in all, of hydrogen, neutral and ionized helium, ionized magnesium, and triply ionized silicon, were measured for the primary purpose of deriving criteria for assigning the stars to their proper places in the *O*-type sequence. The combination of Dr. Petrie's work with that of previous investigators has resulted in making such line intensities available for a total of 28 stars of spectral classes *O*5 to *B*1, inclusive.

As a by-product of his investigation, the Canadian astronomer calculated the absolute magnitudes of 20 stars from the intensities of the K line of interstellar calcium. He found three *O*5 stars to average absolute magnitude —5.0; three in *O*6 to average —5.0; seven in *O*7, —4.8; seven in *O*8-*O*9, —5.1. Thus, these stars are intrinsically nearly 10,000 times as bright as the sun.

In stars of the main spectral sequence, it is possible to compare the relative intensities of certain lines for the purpose of determining absolute magnitudes. In the case of these high-temperature stars, however, Dr. Petrie failed to find a spectroscopic criterion for absolute magnitude from diagrams correlating line intensity and absolute magnitude determined from the interstellar calcium lines. The interstellar lines appear to afford the only index to the individual brightness of an *O* star.

NEWS NOTES

By Dorrit Hoffleit

IRREGULAR-VARIABLE DOUBLE STARS

Double stars and irregular variable stars are not usually found side by side in astronomical discussions. The one class calls to mind extreme orderliness; the other usually raises questions on anomalous, erratic behavior. Dr. A. H. Joy, of Mount Wilson Observatory, studying the spectra of a class of irregular stars known by their prototype as T Tauri variables, has found five of these stars to be double. Dr. G. Van Biesbroeck observed Joy's stars at the McDonald Observatory and measured the separations of the components of the pairs. The separations ranged from less than one second of arc to over 5".7.

Only 11 variables of the T Tauri type are known. The five now known also to be double are RW and UY Aurigae, S Coronae Australis, and UX and UZ Tauri. All are too faint to be seen with the unaided eye. Three are between magnitude 9 and 9.5 (visual) at maximum luminosity, easily seen as single stars with small instruments; while UY Aurigae and UX Tauri are about 11th and 10th magnitude, respectively, at maximum. All are intriguing stars and deserve further observation both as variables and as double stars.

INTER-SCIENCE—INTERNATIONAL CO-OPERATION

Since the beginning of the war, communications between the various co-operating institutions of the international latitude survey have necessarily been discontinued. With the fall of Italy, communication with the central station at Naples has been re-established, according to a recent note from the Committee for the Distribution of Astronomical Literature, and results from measurements for 1935-40 have become available. Several stations in Russia are either in operation or planning to be. No results have come from Batavia since 1940, at which time the Greenwich latitude work was also discontinued. Observations have, however, been continuous at Gaithersburg and Ukiah.

On this side of the ocean, triangulation measurements from the arctic circle in Alaska (66° N.) to latitude 16° N. in southwest Mexico will be useful in studies of the figure of the earth. The utilization of better star positions than were formerly available has led to results indicating that the measured arc from Alaska to Mexico is some 40 feet shorter than was previously supposed. The geodesist depends on the accuracy of the astronomer's star positions, while the astronomer interested in solar parallax depends on the geodesist for the necessary data on the shape of the earth. The accurate determination of all these data requires international co-operation.

126 LETTERS, ALL AT ONCE!

On the occasion of his impending retirement as director of the McCormick Observatory of the University of Virginia, Prof. S. A. Mitchell has been presented an album containing 126 letters of appreciation written by colleagues, former students, and friends. The Leander McCormick Observatory, ably headed by Dr. Mitchell for 30 years, is important for its work in determining stellar parallaxes. While the total number of stars for which trigonometric parallaxes have been determined is about 4,000, at McCormick alone well over 1,000 of these have been measured, largely the result of Prof. Mitchell's efforts. (Of course, many of the same stars have also been measured elsewhere.)

The retiring astronomer is well known for his work on solar eclipses; he is the author of the book, *Eclipses of the Sun,* as well as of numerous contributions to scientific publications.

ASTRONOMY AT THE NEW SCHOOL

Dr. Peter van de Kamp, director of Sproul Observatory, will give a course of 15 lectures on "The World of Stars" at the New School for Social Research in New York City, on Monday evenings, beginning October 2nd. Five lectures will be devoted to each of the topics, The Mechanical Aspect of Stars and Planets; The Stars as Physical-Chemical Units; The Arrangement and State of Motion of the Stars. Further information may be obtained from the New School, 66 West 12th St., New York.

NEW CALCULATOR

What is probably the most efficient calculating machine in the world has been presented to Harvard University by International Business Machines Corporation. The machine, known as the automatic sequence controlled calculator, is the invention of Comdr. Howard H. Aiken, U.S.N.R., on leave as associate professor of mathematics in the Harvard Graduate School of Engineering.

The automatic control feature of the apparatus makes it possible to plan an entire problem or group of problems in such a way as to keep the 72 adding machines, multiplier-divider unit, interpolaters, and other automatic computing and recording devices going practically continually. The problem is presented to the sequence control in coded tape form; other tapes fed into interpolating machines carry mechanical tables of such functions as log x, 10^x, and sine x. With the aid of these functions and arithmetic operations, the elementary functions may be obtained. These include all the trigonometric functions, all the hyperbolic functions, and functions of these functions.

Multiplication is accomplished in a manner not employed previously. When the multiplicand is received by the multiplying unit, this unit immediately sets up the nine integer multiples of the multiplicand and stores them in counters. The process of multiplication is then completed by withdrawing such multiples of the multiplicand as may be indicated by the multiplier, and adding these together while shifting the sum by one column after each addition. Solutions are carried to 23 significant figures.

As in computing units of somewhat similar nature in operation at the U. S. Nautical Almanac Office, at Columbia University, and elsewhere, punched cards may be used for the computational data and recording of results, and results may be automatically set up in tabular form ready for the printer without further proofreading.

Astronomers will be interested to learn that while the calculator is now used exclusively by the Navy, under Comdr. Aiken's supervision, after the war he hopes to set up a computing bureau for scientific and industrial research.

A.A.A.S. CLEVELAND MEETING

The schedule of addresses and symposia for the meeting of the American Association for the Advancement of Science, to be held in Cleveland on September 11th to 16th, includes the annual Phi Beta Kappa address, Wednesday evening, September 13th, by Dr. Harlow Shapley, director of Harvard College Observatory, on the subject, "A Design for Fighting." Several of the symposia will be for the purpose of discussing various phases of postwar international co-operation in science.

BOOKS AND THE SKY

INTRODUCTORY ASTRONOMY. A GUIDE FOR NIGHT WATCHERS

J. B. Sidgwick. Philosophical Library, New York, 1944. 137 pages. $2.50.

THE intelligent layman who knows little or nothing about astronomy will find that this book, with foreword by Dr. Clyde Fisher, starts him off on the right foot in the subject. The text is divided into two equal parts: the first, a summary in seven chapters of the main known facts about the planets, moon, star clusters, and nebulae; the second, well-illustrated descriptions of the individual constellations and directions for finding them.

Worth special mention is the opening chapter, "Why Study Astronomy," in which the author refutes with forceful conviction the all too prevalent idea "that without expensive equipment and a long technical training the pursuit of astronomy must be a waste of time, and the night skies a closed book." On the contrary, he points out, Peltier of comet fame and Will Hay, discoverer of a bright spot on the surface of Saturn, are both amateurs having only the most modest instrumental equipment at their disposal. Anyone with a normal appreciation of beauty and a natural curiosity about the universe in which he lives is a potential amateur astronomer with countless hours of fascinating study, both indoors and out, ahead of him.

Speaking of the outdoor study of astronomy, Mr. Sidgwick has some practical suggestions to offer. Don't, he warns, drink hot tea or coffee just before going out, because its heating effect is only transitory. Drink something hot, instead, when you come in. Wear loose-fitting clothes, two pairs of gloves and socks, and stand on a doormat rather than directly on the ground. Last, but not least, use a stepladder or easy chair to support your binoculars and/or your hands holding them. You can't see faint objects if your binoculars aren't steady! This practical advice closes the first chapter, and leads the reader naturally and logically into Chapter 2 entitled "The First Night Out—Finding One's Bearings."

As the title implies, "Finding One's Bearings" orients the reader with respect to the solar system, so he will not lose his way in the chapters that follow. Eight pages explain simply and clearly the apparent diurnal and annual rotations of the star sphere; the motions and phases of the moon; and what the zodiac is. Chapter 3, on the planets, discusses the structure of the system and the apparent motions of the planets; then takes up each planet individually and tells when and where to look for it.

The author next turns attention to the moon, describing its distance, diameter, motions, relation to eclipses, and topography. Amateur observers will find especially useful the list of objects for binocular study at the end of this chapter. Asteroids, comets, and meteors are the next topics discussed, and after these comes a chapter on the stars; then one on the galaxy, star clusters, and nebulae, which ends the first half of the book.

The second half of the text summarizes in tabular form salient facts concerning the sun, moon, and planets, and treats in detail 50 of the constellations. Four maps showing the appearance of the night sky on different dates throughout the year start the reader off on his tour of exploration. Excellent original charts of the individual constellations identify each star and indicate its magnitude. Featured on these charts is a unique and useful scale representing a 6-inch rule held at arm's length. Subtending a definite angle, this gives the observer a means for measuring distances in the sky, and enables him to determine from the map the apparent size of the constellation for which he is looking.

JANE S. DAVIS
New York A. A. A.

ROCKETS

The Future of Travel Beyond the Stratosphere. **Willy Ley.** The Viking Press, New York, 1944. 287 pages. $3.50.

TO those concerned with astronomy and things astronomical, this new book on man's conquest of space by use of the rocket principle should prove interesting and challenging. Mr. Ley attempts to picture such travel in the places beyond our immediate reach, in the regions above the stratosphere, outward to the last layer of atmosphere, and on through the void of space to the moon and our sister planets. He attempts to show that meteorological rockets are already feasible for penetrating far above the altitudes reached by present sounding balloons, and further, that with the experience gained from this preliminary work, the "grand problem" (space travel) will begin to show signs of nearing a final solution.

In order to obtain an understanding of this problem it is necessary to approach it without bias. More than most other fields, this one of rocket travel has been subject to abuse and ridicule —so much so that though many are interested, only a few have the fortitude to engage openly in its research.

Are the astronomical facts correct? Are the engineering calculations reliable and consistent with the known data accumulated from the European and American research to date? These are the challenges. If the facts are un-

NEW BOOKS RECEIVED

Geology Applied to Selenology, *J. E. Spurr*, 1944, *Science Press.* 112 pages. $3.00.

A detailed discussion of lunar features in the Mare Imbrium region, from a geologist's point of view.

shakable, and the development of the problem found logical, a stimulus is provided for further thought along these lines.

From astronomy we learn that each planet and sun has its own easily calculated velocity of escape, that for the earth being seven miles a second. However, in considering a trip to Mars—the favorite calculation since this is the planet giving most evidence of supporting life—the escape from earth would have to be followed by a braking maneuver to reduce the orbital speed from 18.5 to 15.0 miles per second, or a landing would be impossible. In addition, another braking would be needed to counteract the falling speed to the surface of Mars, which, of course, would be its own escape velocity of about three miles a second. All of these figures, and more, are given in Ley's book, along with the result of calculations made by Oberth, Hohmann, and several other Europeans, as well as those of our own pioneer in this field, Prof. Robert H. Goddard, of Clark University, far back in 1919.

Thus it may be said that one of the questions involved in space travel, the various gravitational forces to be overcome, can be answered by our present knowledge of astronomy. At least we are not ignorant of the requirements for a solution. With the problem fairly outlined, what about its practical realization? Here is where most of the dissension begins. Mr. Ley sifts through the results of many enlightening calculations. All point to the fundamental trouble of fuel with insufficient energy. If the atomic energy released by the fission of uranium 235 could ever be produced in practical amounts, the principal obstacle to space travel would be surmounted.

Yet, as the author points out, the step principle, to utilize more effectively present fuels such as gasoline, oil, or alcohol, with liquid oxygen, was proposed in 1911 by Bing and later again by Goddard and Oberth. The dropping off of empty tanks after a high velocity is reached makes each succeeding lot of fuel more effective.

In addition to the scientific background of the subject, which Mr. Ley presents in a readable way, there are entertaining anecdotes by the dozens which could have been assembled only after a thorough job of research. The bibliography is excellent.

A personal note about the author may be of interest in closing this review. In the early part of 1935, Germany became too hot for Willy Ley's political beliefs and so he decided to come over to try his luck with us. Ley was vice-president of the German Rocket Society and had been doing a great deal of writing and lecturing on the subject. But 1935 was not the year of the bazooka. Most of us then engaged in testing and writing about rockets had other more mundane ways of earning our living, reserving weekends and evenings only for this fascinating avocation. From the next room to Willy's in a Greenwich Village rooming house during that period, I heard his typewriter going night after night as he wrote popular science articles on a wide range of subjects. With the publication of **Rockets**, for which some of the material was being prepared even then, Willy Ley has compiled for the average reader one of the most comprehensive books on rockets to date.

ALFRED AFRICANO
American Rocket Society

SCIENCE AT WAR

George W. Gray. Harper and Brothers, New York, 1943. 296 pages. $3.00.

IN HIS preface the author says, "The term science is used in this book in a comprehensive sense . . . . So the reader is to understand by science the work of all who are engaged in exploring nature or in harnessing its forces." To put between the covers of a single book an account of science at war is certainly an ambitious undertaking. To the author's credit it can be said that virtually every significant aspect of the use of science in the American war effort has been treated. Mr. Gray's account is organized in such a way that the place of each development in the overall pattern of the war effort is clearly seen.

The level of the book is set for the

(Continued on page 19)

SKY-GAZERS EXCHANGE

Classified advertisements are accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge 38, Mass.

GLEANINGS FOR A.T.M.s

Questions and Answers

Q. Would a test on this principle be practicable? A pinhole source of light moving across the face of a mirror is opposed by a sensitive photoelectric cell moving synchronously across the back of the mirror. The cell is connected with a suitable meter.

Bertram C. Felsburg, U. S. Army

A. We doubt if the above test would be practical. The reading of the meter would depend upon the thickness of the glass of the mirror, due to absorption, and the variations in thickness would be so minute that it is questionable whether any photoelectric cell would be sufficiently sensitive to give a result. Furthermore, glass used in mirrors, especially Pyrex, is not by any means homogeneous, and variations in absorption due to non-homogeneity would be far greater than variations due to the differences in thickness that the test would be designed to measure.

Q. If a small section of a large mirror is made and mounted on a turntable and revolved at a speed sufficient to avoid jerkiness or blinking, would not the effect be equivalent to that of a large mirror? Such a segment could be made with a fraction of the trouble found in making an entire round mirror.

Emile F. Miguery, Ronan, Mont.

A. This operation involves the effect of a moving mirror upon light. A mirror in rapid motion reflects light differently than a mirror at rest, and this effect would overcome the increase in resolving power which might be attained. The gain in resolving power would be the only advantage to such an arrangement, and resolving power is a minor consideration in deciding upon the size of a prospective mirror. Light-gathering power is the all-important consideration, and this can only be achieved through a large area of mirror reflecting light continually, not intermittently. Such a sectional mirror as is suggested by this question would have to be figured "off-axis"—a difficult task.

Q. In the original patent for the Schupmann telescope (see The SKY, Sept. 1941), it would seem that the designer mentioned the possibility of mounting the reflector-corrector at an angle so as to avoid the necessity of the diagonal immediately in front of the objective—a modified Herschelian arrangement. Would this arrangement work satisfactorily or not?

Dr. Henry Powers, Palo Alto, Cal.

A. We cannot find any particular theoretical objection to tilting the correcting mirror so as to throw the beam of light off to the side sufficiently to mount the eyepiece diagonally in the side of the tube. The definition would probably be unsatisfactory unless the correcting mirror were figured off-axis, that is, representing a section of a much larger theoretical mirror, and this might be a difficult manufacturing proposition. Furthermore, the position of the eyepiece resulting from this arrangement might be inconvenient for observing.

Q. Will a prism with a 2½-inch entrance face introduce significant color error in a Newtonian telescope?

George Stoneman, Sevenoak, Kent, England

A. The color error introduced by a prism used as a diagonal depends entirely upon the convergence of the rays which enter it. If it were possible for all the light to enter the prism perpendicularly to the entrance face, no color would be introduced. Therefore, the question can only be answered by knowing the focal length of the mirror in question. If it is reasonably great, the effect will be insignificant; in any but unusual cases, the eyepiece will probably introduce more chromatic aberration than the prism. In any case, a large prism for a large mirror will be no more objectionable than a small prism for a small mirror.

There is another point, however. A prism as large as the inquirer suggests will be quite expensive, and an elliptical flat, well made, will be much cheaper and probably perform more satisfactorily.

Q. How large should the cone of light from the pinhole be at the mirror in the Foucault test? Should it just cover the mirror? What should the distance be from the pinhole back to the actual source of the light? If too close, the effect would be equivalent to an oversized pinhole; and if too far, the mirror would not be covered by the light.

R. A. Bell, Port Clinton, Ohio

A. If the pinhole is as small as it should be, it will act as an independent point source of light. This is the purpose of the pinhole, and when it acts in this way, the cone of rays proceeding from it covers an entire hemisphere. Theoretically, the size of the pinhole should be of the order of .001 mm., but it is difficult to make a pinhole this small, and even if one is available, a tremendously powerful light source is necessary to give sufficient illumination. If the pinhole is too large, that is, if it is so large that it gives a cone rather than a hemisphere of rays, the mirror will form an image of the original light source (filament) instead of an image of the pinhole, and the principle of the test is nullified. To prevent this possibility, it is better to back up the pinhole with translucent material, such as frosted glass. When this is done, as well as when the pinhole is sufficiently small, the only consideration in determining the distance of the source behind the pinhole is that of illumination, which, obviously, is greater the nearer the source is to the pinhole. Therefore, we can say, make the pinhole as small as possible, back it with frosted glass, and then place the light source as close

to the pinhole as possible, in order to get all the light possible. Most amateurs prefer a slit, which gives a great deal more light and, while not quite as sensitive as a pinhole, is usually sufficiently accurate for good results.

Q. How does the number of stars that can be seen through a large telescope compare with the number shown photographically? For example, M13 as shown on the back cover of **Sky and Telescope**, July, 1943. How does this compare to the RFT? R. A. Bell

A. This question requires a rather involved answer. The number of stars to be seen in a given field of view depends upon four factors: 1. The resolving power of the telescope. 2. The magnifying power being used. 3. The angular field of view. 4. The number of stars actually in the region down to the limiting magnitude of the telescope. The second and third factors are interdependent.

In the case of a photograph, the factors involved are: 1. The resolving power of the telescope. 2. The number of stars actually in the region of the sky. 3. The focal ratio of the telescope. 4. The length of the exposure and the sensitivity of the emulsion to various wave lengths of light.

Comparison between results visually and photographically can only be made for a given set of conditions. In the case mentioned by the inquirer, that of a globular cluster, many more stars will be seen in a photograph than with the eye, because it is only necessary to give a sufficiently long exposure to bring out stars on the photograph which are beyond the limiting magnitude of the same instrument when used visually. Usually, also, the area covered by the photograph is much greater than the area of the visual field of view.

BOOKS AND THE SKY

(Continued from page 17)

intelligent but scientifically uninformed reader. Whenever a little scientific background is necessary for the understanding of the author's description of a new weapon or device, that background is supplied. Even for a person who has followed the published reports of all the developments described in **Science at War**, most of which have appeared in popular print, it should be instructive and entertaining to read about them once again in a comprehensive account.

Of the nearly 300 pages in this volume, the first 60 are devoted to a historical survey of science in earlier wars and the relation of the scientific war effort in those wars to our present organization. This introductory survey is concluded by a detailed description of the Office of Scientific Research and Development, the chief organization of the United States government for war research.

The chapter on applied physics, entitled "Force, Force to the Utmost," discusses with appropriate historical excursions the new developments in various types of projectiles of all sorts, together with recent developments in planes, ships, guns, and tanks. Attention paid to the newer missiles and rocket projectiles is perhaps disappointingly brief, but it must be remembered that when the book was written, security restrictions on these topics were more severe than at the present time, and public interest had not been aroused by such developments as the German long-range jet-propelled flying bomb.

"Electric Warfare" considers the application of electronics and other branches of electrical engineering to the devices of warfare. Radar is described in some detail. Consideration is also given to underwater sound devices, mine sweepers, and various kinds of fire-control devices. Closely integrated with this chapter is a brief one on the use of mathematics as a tool in solving the engineering problems of warfare.

The chapters on the newer chemical developments are to a considerable extent historical, although some space is given to recent advances in the production of explosives and, particularly, of high-octane fuels in quantity. Recent work in the chemistry of high polymers and their application to the war effort in the form of synthetic rubber, synthetic fibers, plastics, and the like, and newer developments in the field of metallurgy, are also considered.

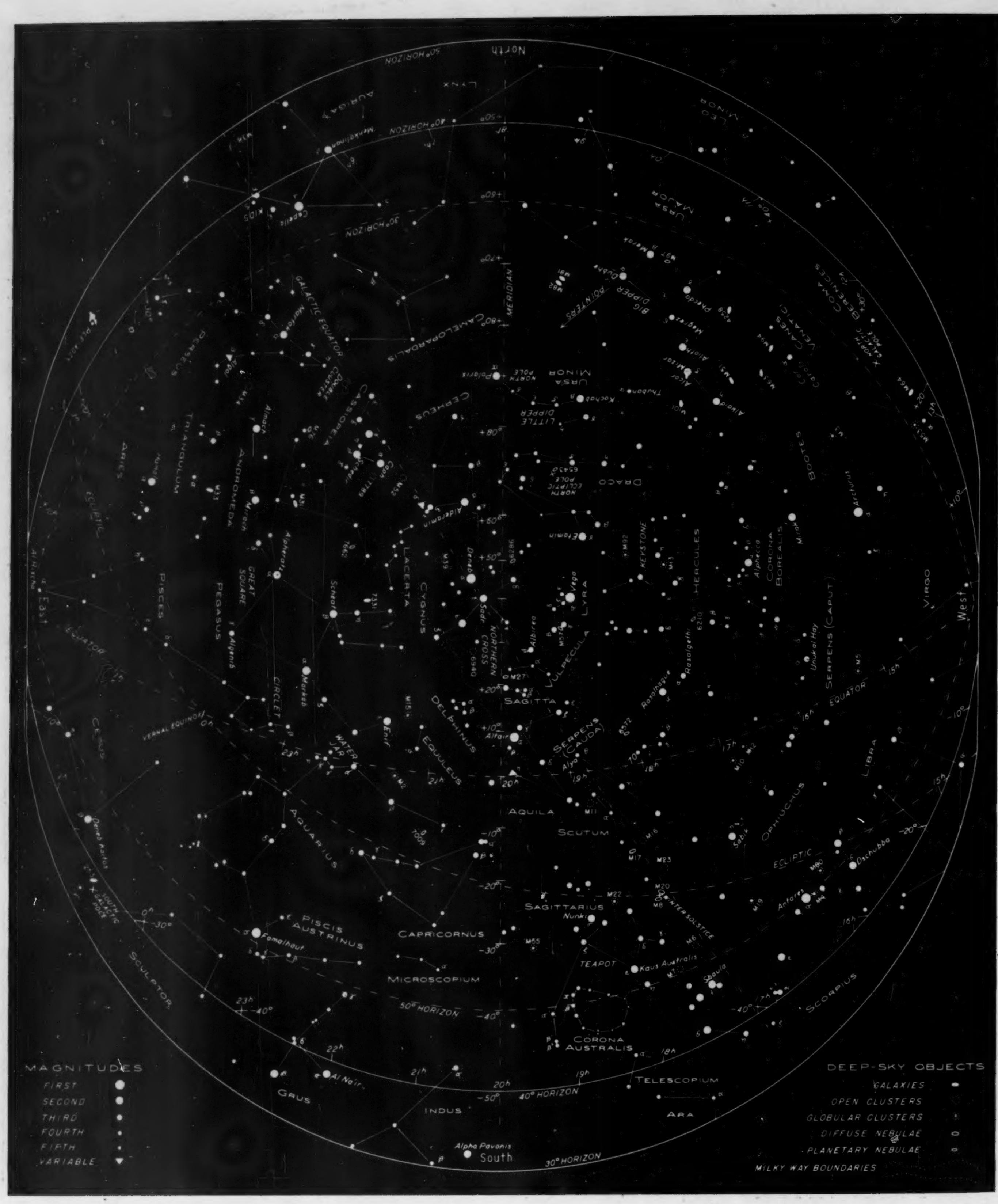
Next there follow two fascinating chapters on war medicine. As everyone knows, the historical trend in warfare has been such that the ratio of noncombat casualties to combat casualties has been steadily decreasing, and only in wars of the last half century or so has this ratio been smaller than one. The reduction of the ratio to an unprecedentedly small value in the present war has been associated in large part with the dramatic developments in chemotherapy. A brief discussion on the organization of the Committee on Medical Research, the medical division of the O.S.R.D., is also included.

The second of the chapters on medical warfare is devoted exclusively to aeromedicine, and benefits from the fact that this field is surrounded by fewer security restrictions than other scientific aspects of the war effort. The discussion is considerably more thorough, and, to the reviewer at least, is one of the most interesting parts of the entire book. The influence of prolonged high-altitude flying on the human mechanism, the physiological effects of variously directed high accelerations, and the psychological toll of air combat are taken up in detail.

In "The War of Ideas," Mr. Gray's final chapter, are discussed the phenomena associated with psychological warfare and the "war of nerves." He describes the uses of propaganda on the part of both the totalitarian powers and the United Nations.

The book closes with an epilogue on "Science in the New World," in which the impact of scientific and engineering developments arising from the war effort on post-war civilization is considered in broadly general terms.

RICHARD C. LORD
Johns Hopkins University



DEEP-SKY WONDERS

AMONG marvels for observation in the September skies are the objects listed here. The informal descriptions give appearance in common telescopes.

Sagittarius. M23, 17^h $51^m.0$, —19° 00′; a cluster of 120 stars. M20, 17^h $57^m.5$, —23° 02′; the Trifid nebula; in large amateur telescopes there are three dark lanes, with a double star where they meet. M8, 17^h $58^m.8$, —24° 23′; the Lagoon nebula, with a cluster of stars; black lane between two nebulosities, like a sandwich. M22, 18^h $33^m.0$, —23° 58′, and M55, 19^h $36^m.6$, —31° 04′; two large globulars, just visible to the unaided eye, rivals of M13 in Hercules.

L. S. COPELAND

CORRECTION TO THE CHART

The planetary nebula at +50°, near the meridian, is NGC 6826, not 6286.

STARS FOR SEPTEMBER

from latitudes 30° to 50° north, at 10 p.m. and 9 p.m., war time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

BEGINNER'S PAGE

By Percy W. Witherell

Man and His Expanding Universe — X

ASTRONOMERS for many centuries observed, listed, and made charts of the positions of the stars, and recorded their apparent magnitudes or relative brightnesses. To measure the stellar distances was a more difficult problem. Patterning their observations after the surveyor's trigonometric method, astronomers a century ago first used the distance across the earth's orbit, or a portion thereof, as a baseline. In some cases it is possible to compare positions of a star at six-month intervals, when the earth has been displaced the diameter of its orbit: 186 million miles; in other instances, depending on the location of the star and of the observatory, smaller intervals than this must be used. In any case, however, the change in position of a bright star against the background of much fainter stars (presumably much farther away on the average) gave the necessary information to determine the star's distance in terms of the radius of the earth's orbit.

The angle at the star that is subtended by the earth's orbital radius is the stellar *parallax*. By modern methods, developed by the late Frank Schlesinger at the turn of the century, observatories possessing long-focus refractors, such as Yale's southern station, Allegheny, and Leander McCormick, measure 10 to 20 or more plates of a region on very precise measuring machines. To procure the plates requires a number of years, and the measurements need skill and patience, so that today directly measured parallaxes are counted only in the thousands.

Sirius, the brightest star, is some 54 million million miles from us, while Alpha Centauri, the nearest known star to the sun, is about 25 million million miles away, so that its light takes about 4¼ years to reach us. At its distance, the astronomical unit (distance from earth to sun) makes an angle of only about 3/4 of a second of arc, or about 1/1,728,000 of a whole circle!

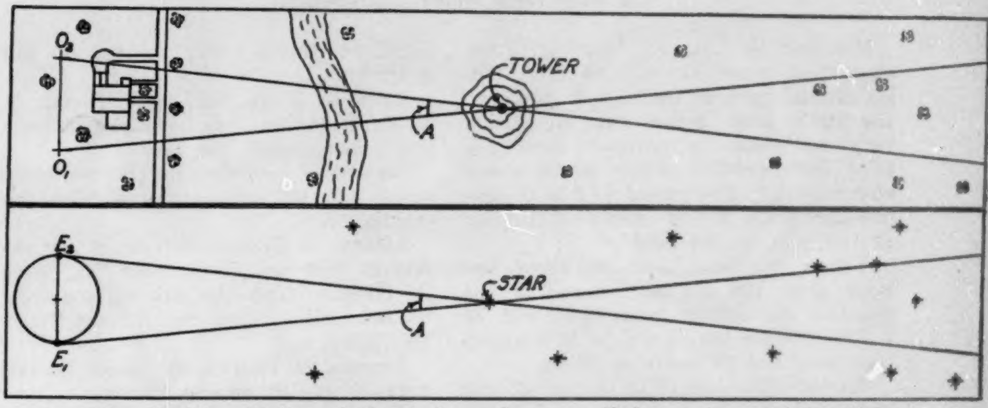
One of the chief advantages of trigonometric parallaxes, which are fairly accurate for stars within 200 light-years (1,200 million million miles), is to check the accuracy of other ways of ascertaining the distances of the stars. If other methods show comparable results for the nearer stars, the astronomer can use them for the more distant objects with greater confidence.

From time immemorial the Milky Way attracted the attention of mankind, but it was not until the telescope revealed some of the individual stars that any conception of its true nature was realized. Sir William Herschel was one of the first to show by actual observations and counts of stars that the existence of a watch-shaped arrangement of stars located in the plane of the Milky Way would explain the immense concentration of stars in every direction in that plane. The comparative thinness of the system would explain the much lesser number of stars we see when looking at right angles to the plane of the Milky Way (galactic equator), that is, when we look toward the north pole of the galaxy, in Coma Berenices, and toward the south pole, in Sculptor.

Careful study of the movements of stars across the sky (*proper motions*) antedated the measurement of their distances by more than a century. It was Edmond Halley, of comet fame, who first showed that Arcturus and Sirius were changing their positions among the stars, so that stars could no longer be regarded as "fixed." Although rapid strides were made in the measurement of stellar motions, it was not until the present century that sufficient information became available to prove that stars in the Milky Way galaxy were in rotation around a common center. It had been thought, of course, that such rotation was necessary for the dynamical equilibrium of such a flattened system. The study of the motions of the stars including their motions in the line of sight (radial velocities determined from shifts in the lines in stars' spectra) finally showed that the center of rotation is in the direction of the stars in Sagittarius. This also explained the density of the stars in that direction, where they are more abundant than in any other part of the sky, for we are looking toward the region of greatest concentration about the galactic center. It is now thought that the *cosmic year*, or time for the sun and its planets to turn once around the galactic center, is about 200 million years; the distance to be covered is so great that the sun must travel about 150 miles per second along its galactic orbit.

How big is our galaxy? This problem has been studied for many years. The evidence seems to show a probable diameter in excess of 100,000 light-years and a thickness of about 10,000 light-years. There seems to be a central nucleus extending over about a quarter of this area. Harlow Shapley has recently shown "the existence of a spherical haze of stars surrounding the ellipsoidal system" mentioned above. Our sun is about 30,000 light-years from the center and a little above the central galactic plane. This latter position is revealed by the fact that the Milky Way in the sky seems to be slightly displaced to the south of the galactic equator, which is itself, of course, a great circle on the sky.

Incidentally, it may help our inferiority complex to learn that our sun is not quite so insignificant in the star family as formerly supposed. Of all the known stars located within 16 light-years of us, our sun is surpassed in absolute brightness by only four and is superior in candlepower to the other known 42 stars within this sphere of space. There is also the possibility that the discovery of more invisible dwarf companions and of other faint stars may increase the number of those in the latter group.



The principle of triangulation is here shown applied to a terrestrial problem and to the problem of the heliocentric parallaxes of the stars.

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern war time.

Variation of Saturn's Perihelion

SEPTEMBER brings to mind the oft-told but always stirring story of the discovery of the planet Neptune because of unexplained discrepancies in the motion of Uranus. That was nearly 100 years ago, when a major part of astronomy concerned itself with the motions of the members of the solar system. Today, positional astronomy is often neglected by the amateur in favor of astrophysics, but the study of planetary motions can be of considerable value to the amateur who develops the habit of using his **American Ephemeris** frequently and thoroughly.

The displacement of Saturn's position at perihelion on September 8th this year, that is, the difference between the mean longitude of its perihelion and its actual position on that date, amounts to more than 1° 10′ of longitude. It was a discrepancy of this order which had accumulated in the case of Uranus when Leverrier made his remarkable prediction of the place in which Neptune should be found. This year, in Saturn's case, the discrepancy is easily noted by referring to the following facts in the **Ephemeris**:

On page xvii, the mean longitude of Saturn's perihelion is given as 91° 57′ 03″.4; on page 221, the heliocentric longitude of the planet is given as 91° 55′ 28″.4 on August 7th, and as 93° 07′ 13″.4 on September 8th. Also on page 221, the logarithm of the radius vector on August 7th is 0.9556369, and on September 8th it is 0.9556323, with the variation of the radius vector per day on September 8th 0.0.

Thus, although Saturn's direction from the sun on August 7th was practically that of its mean perihelion, it actually approaches the sun closest on September 8th, by which time it has moved 1° 12′ farther to the east. When I first noticed this discrepancy in Saturn's apparent and expected positions, I wrote to Dr. Dirk Brouwer, director of Yale University Observatory, seeking an explanation, and he very courteously sent me the following lucid reply:

"Your question concerning the longitude of the perihelion of Saturn interested me a good deal. I have looked up the theory of the motion of Saturn by Leverrier. This is the most convenient source for this kind of information. The principal effects of the attraction of Jupiter upon the longitude of the perihelion of Saturn produce a change in the position of minimum radius vector of the planet in its orbit amounting to +1°.32 sin D, where D is the difference in mean longitude between Jupiter and Saturn. This angle is 49°.1 on January 1, 1944, and increases by 18°.127 per tropical year.

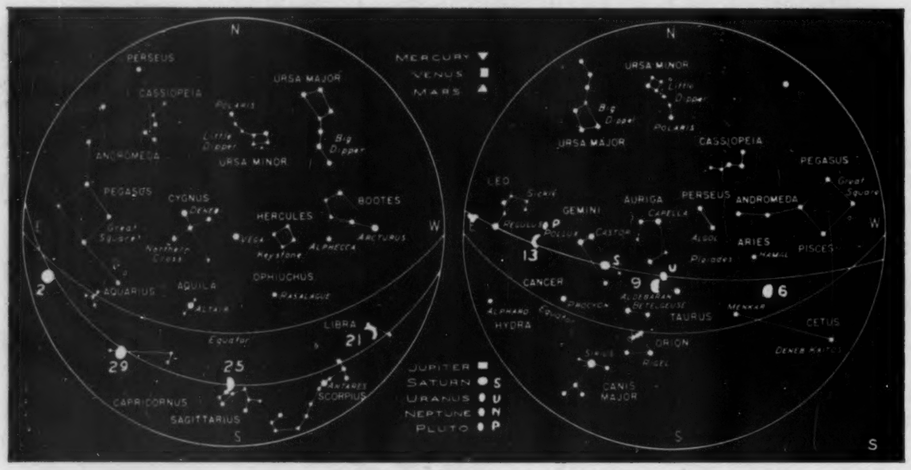
1944 Sept. 8 = 1944.69
D = 61°.55
sin D = +.879
1°.32 sin D = +1°.16

Perihelion freed from periodic terms is 91°.97. Adding the principal periodic terms of +1°.16 gives a perihelion affected by periodic terms of 93°.13.

"This corresponds very closely to the longitude of Saturn at the time of minimum radius vector on September 8th. However, I have tried the same computation for a few earlier dates of minimum radius vector and find deviations that must be due to other periodic terms. The agreement is apparently unusually good, by accident, this year."

When Saturn was at longitude 91° 57′ on August 7th (where it should be on September 8th were it not for Jupiter's attraction) it appeared in the sky 2° 14′ north of Nu Geminorum (magnitude 4.1). When at perihelion on September 8th, at heliocentric longitude 93° 7′, it will be 2° 55′ slightly southwest of Epsilon Geminorum (magnitude 3.2). The observer who wishes to watch its motion in the morning skies this month will have opportunity to see just how much Jupiter has pulled it out of position.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 8:30 p.m. on the 7th and for 7:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury, in Leo, will be at greatest elongation west, 17° 52′, on the 22nd. Its diurnal path in the sky, 8° north of the sun's path, makes this elongation very favorable in northern latitudes. (See last month's article on Mercury elongations.) The planet will be in conjunction with and 6′ north of Jupiter at 1:00 p.m. on the 23rd.

Venus, in Virgo, will set about one hour after the sun at the end of the month. Its stellar magnitude will be —3.3. On the 9th, it will be in conjunction with and 28′ north of Mars.

Earth. The sun will arrive at the autumnal equinox at 0:02 a.m., September 23rd, and autumn will begin in the Northern Hemisphere; spring in the Southern.

Mars, in Virgo, will be 48′ north of Neptune on the 3rd, both planets setting shortly after the sun.

Jupiter, in Leo, rises nearly two hours ahead of the sun at the end of the month.

Saturn, in Gemini, will be at perihelion at 8:00 p.m., September 7th, when its distance from the sun will be 839,683,000 miles. See special article in this issue.

Uranus, in Taurus, will start its retrograde motion on the 18th.

Neptune, in Virgo, will be in conjunction with the sun on the 27th.

OCCULTATIONS FOR TEXAS

Predictions are for longitude 98° 0′.0 W., and latitude 30° 0′.0 N. The data include: date, name of star, magnitude; G.C.T. in hours and minutes, a and **b** quantities in minutes, and position angle, at immersion; G.C.T., a and **b** quantities, and P.A. at emersion.

The predictions, computed voluntarily by Miss Tecla Combariati and J. Lynn Smith, of the U. S. Naval Observatory, are similar in form to those given in the **American Ephemeris** for 1944, pages 365-372.

Immersions at the dark limb (while the moon is waxing) are most desired. Reports should include the exact time of the phenomenon, and the observer's precise latitude, longitude, and elevation.

Sept. 1, 30 Cap, 5.4; 5:22.7, —1.3,

REQUEST FOR BACK NUMBERS

TO FILL an unprecedented number of requests from our subscribers for certain back issues which we are unable to supply, the circulation department of *Sky and Telescope* will pay the cost and postage for any of the following numbers in reasonably good condition:

Vol. I, Nos. 3, 4, 6, 8, 11, respectively being January, February, April, June, and September, 1942.

These should be sent flat in an envelope, preferably with cardboard, to Circulation Dept., Sky and Telescope, Harvard College Observatory, Cambridge 38, Mass.

+2.2, 25°; 6:21.0, —2.8, —1.4, 293°.

Sept. 10, Chi^1 Ori, 4.6; . . . ; 7:33.6, +0.6, +2.8, 207°.

Sept. 26, 28 Sgr, 5.8; 1:58.9, —2.4, —0.1, 80°; 3:24.6, —1.8, —0.8, 271°.

Sept. 26, 30 Sgr, 6.2; 4:46.2, —0.6, +0.1, 55°; 5:46.3, —0.8, —1.5, 287°.

Sept. 30, 74 Aqr, 5.9; 6:53.5, —2.9, —2.3, 115°; 7:34.3, +0.2, —2.8, 186°.

PHASES OF THE MOON

Full moon ...	September 2, 4:21 p.m.
Last quarter .	September 9, 8:03 a.m.
New moon ...	September 17, 8:37 a.m.
First quarter .	September 25, 8:07 a.m.

MINIMA OF ALGOL

Sept. 17, 2:50 a.m.; 19, 11:39 p.m.

PHILIP FOX

(Continued from page 2)

cessful photographs, he initiated a program of trigonometric parallaxes. As one of the early workers on a problem which is among the most exacting in its observing techniques, he encountered difficulties which he fully investigated and described in the introduction to his published volume of parallaxes. His devotion to accuracy in every detail was one of his outstanding characteristics. During this time, he also gave his time and care so generously to the instruction and guidance of students that their astronomical education was limited only by their own interest and ability.

This work as research astronomer and teacher was interrupted in 1929, when he left Northwestern University and devoted his time to the planning and perfecting of the Adler Planetarium and Astronomical Museum. This was the first planetarium in this country and has many unique features. The striking building jutting into Lake Michigan houses, besides the planetarium instrument, an important and beautiful collection of old astronomical instruments which was brought to this country through the interest of Prof. Fox. In addition there are exhibits and models of modern instruments which are of great interest and instructive value to visitors.

What he did for the planetarium, he had to do on a bigger scale for the Museum of Science and Industry, to which he went in 1937. An enormous undertaking, the museum presents not only historical exhibits but endeavors to give its visitors a sound understanding of science and its industrial applications. Extensive use is made of models, most of which are so ingeniously planned that the visitor can set them into motion himself and watch the exhibit as it explains some principle of one of the sciences, ranging from agriculture to pure mathematics.

Prof. Fox always took an active interest in the scientific societies of which he was a member, and served as secretary and vice-president of the A.A.A.S. (section D), and as secretary, councilor, and vice-president of the American Astronomical Society. He was also chevalier of the Legion of Honor and officer of the Ordre du Saveur de la Grèce, following his work as major and assistant chief of staff of the seventh division in World War I.

Just before World War II began, he was called to active duty as colonel of infantry, and in 1942 was stationed at Harvard as commanding officer of the Signal Corps electronics school at Harvard and Massachusetts Institute of Technology. The army was fortunate in finding in him a man capable of understanding both scientific and army problems. After his retirement from the army in 1943, he remained at Harvard as a civilian member of the staff until his death in July, 1944.

To this recital of the outstanding events in his career, there must be added a word about his devotion to his children, his interest in painting, music, and poetry, and his understanding and loyalty to his friends. His recent death is felt keenly by us all.

CAROL ANGER RIEKE

OCCULTATIONS—SEPTEMBER, 1944

Local station, lat. 40° 48'.6 north, long. 4^h $55^m.8$ west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Sept. 1	5.4	30 Capricorni	1:59.3 a.m.	31°	2:53.2 a.m.	287°
10	4.6	Chi^1 Orionis	3:17.3 a.m.	126°	4:00.4 a.m.	207°
14	6.3	12 B Leonis	4:05.3 a.m.	115°	5:01.6 a.m.	259°
19	5.8	80 Virginis	7:02.7 p.m.	111°	8:08.6 p.m.	292°
24	4.9	58 Ophiuchi	7:07.7 p.m.	87°	8:32.0 p.m.	283°
25	5.8	28 Sagittarii	10:33.9 p.m.	74°	11:41.8 p.m.	272°
26	7.2	BD —22° 5183	7:19.2 p.m.	77°		
30	5.9	74 Aquarii	3:14.4 a.m.	114°	3:52.9 a.m.	197°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *September*, AROUND THE WORLD IN 50 MINUTES.

Vacation tours are "out" for the duration, but the magic of the planetarium projector takes visitors this month on a world tour in an hour—under the stars of the tropics, under the skies of the frozen polar regions. As we seem to move about on this round earth, we see, as so many of our service men have really seen, what different vistas of the starry heavens are presented to Australians and South Americans, Russians and Chinese. We find places where June means winter, and where the sun rises just once a year. We see the southern lights, meteors in the Antarctic, and an eclipse in the Philippines. Even in wartime we can get the globe-trotter's point of view.

★ **THE HAYDEN PLANETARIUM** presents in *September*, A TRIP TO THE MOON.

In *October*, SKIES OF AUTUMN. Many a navigator winging his way through the air or sailing across the vast blue of the sea will be watching these same stars. Do you know their names and to what constellations they belong? This month we shall show you some easy ways to identify the more important stars.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays (except Tuesdays) .... 3 and 8:30 p.m.
Sundays and Holidays .... 3, 4, and 8:30 p.m.
(Building closed Tuesdays)

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★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays .... 2, 3:30, and 8:30 p.m.
Saturdays .... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays .... 2, 3, 4, 5, and 8:30 p.m.

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